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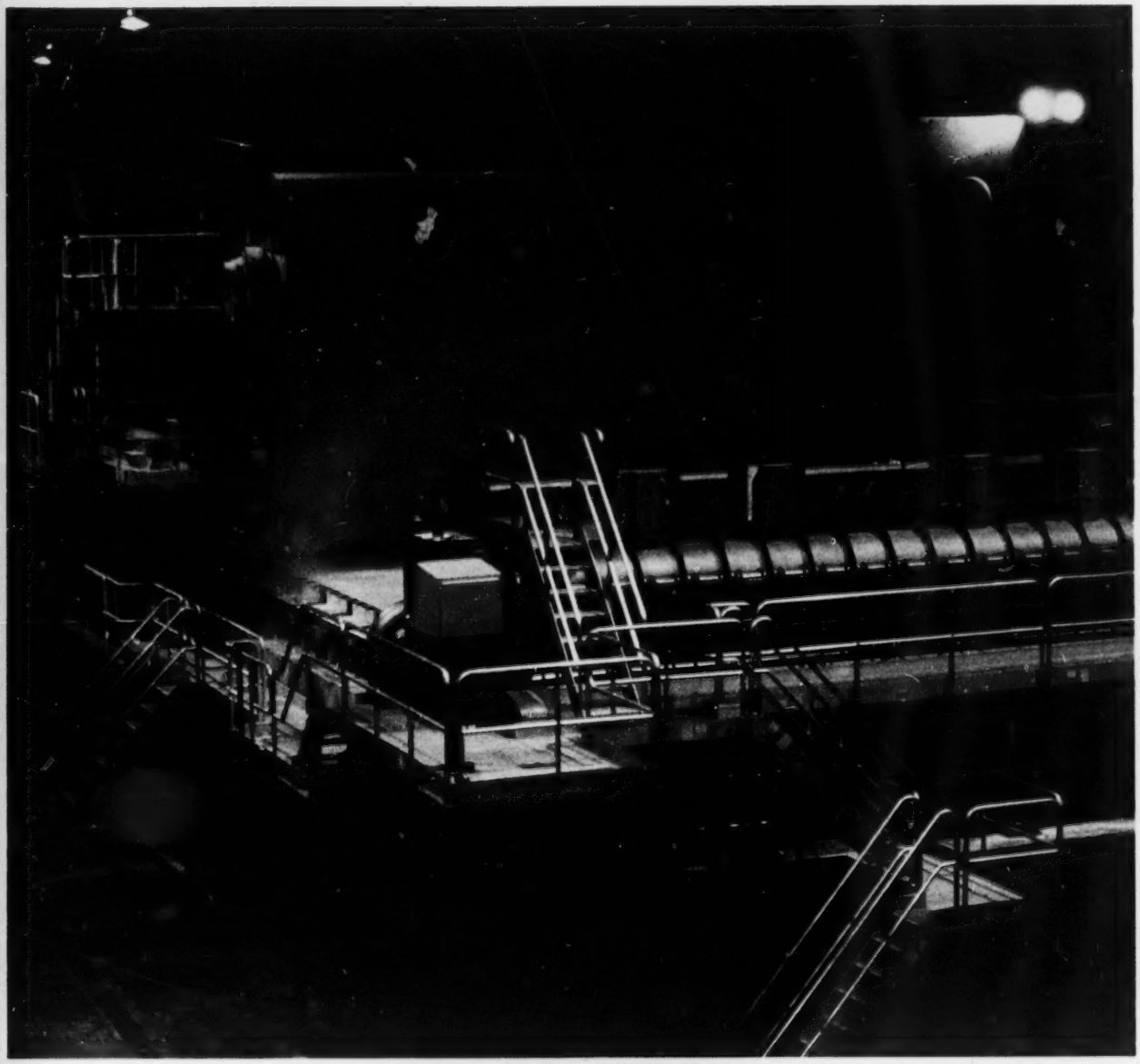
PULP & PAPER
April 1987



SPECIAL REPORT:
Quality: Putting U.S. paper products to the test
Sponsored by The Dow Chemical Company

COVER STORY:
Hammermill starts up uncoated free-sheet machine at Selma **89**

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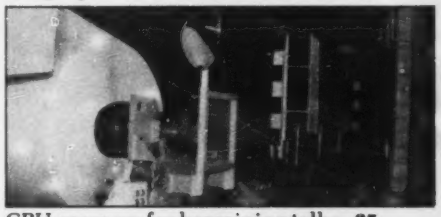

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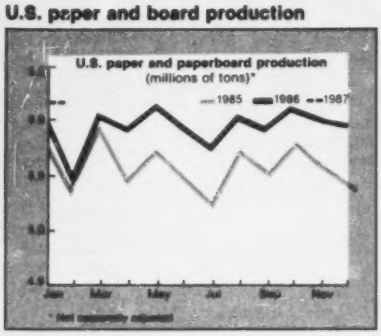
MONTH IN STATISTICS

U.S. paper and board production



U.S. production of paper and paperboard climbed to 6.2 million tons in January, up 4.7% compared with January 1986, according to the American Paper Institute. Growth in paperboard production easily outstripped paper, although both sectors remained at record high levels. Paperboard operating rates for 1987 were averaging about 97% through mid-February, the API reports, compared with a 94% rate for paper. The seasonally adjusted trend rate stood at 73.4 million tpy in January, 4.4% above last year. Production was in line with fourth-quarter 1986 results, which got a strong boost in December.

Among major grades, growth trends continued to be strong in newsprint, up 5.9% compared with January 1986, and coated papers, up 8.7%. Production was strong in all of the paperboard grades, led by a 10.4% increase for semichemical board. Corrugated box shipments continued at record highs, although containerboard inventories rose slightly to 5.9 weeks of supply.

Canadian newsprint shipments totaled 750,000 metric tons in January, 5.2% above the comparable 1986 month. Woodpulp exports jumped 8.3% to 610,000 tons, with operating rates climbing to 98%, up from 88% a year earlier. ■

		Latest month (000 short tons)	% change from year ago	Annualized year-to-date (000 short tons)	% change from year ago
PAPER & PAPERBOARD PRODUCTION[1]					
Newsprint	Jan.	490	5.8	5,884	5.9
Uncoated groundwood (s)	Jan.	134	4.7	1,613	3.4
Coated paper (s)	Jan.	566	8.6	6,793	8.7
Uncoated free sheet (s)	Jan.	893	0.4	10,717	0.3
Other printing/writing	Jan.	114	−1.7	1,366	−2.1
Total packaging and other paper (s)	Jan.	446	2.3	5,350	2.2
Tissue	Jan.	412	−3.7	4,938	−5.0
Total paper	**Jan.**	**3,055**	**2.5**	**36,660**	**2.1**
Unbleached kraft paperboard	Jan	1,546	5.8	18,548	5.8
S michemical medium	Jan.	481	6.6	5,777	10.4
Bleached paperboard	Jan.	381	7.3	4,572	7.4
Recycled paperboard	Jan.	735	7.9	8,822	6.2
Total paperboard	**Jan.**	**3,143**	**6.9**	**37,719**	**6.8**
Total U.S. paper and paperboard output	**Jan.**	**6,198**	**4.7**	**74,379**	**4.4**
PULP, WASTEPAPER & FIBER[2]					
Total U.S. woodpulp production	Dec.	4,901	11.8	57,252	5.7
Market pulp production	Dec.	692	24.9	7,571	11.3
Wastepaper consumption at paper/board mills	Dec.	1,339	10.9	16,579	8.5
Pulpwood consumption (cords)	Dec.	7,795	12.9	91,434	6.6
CONVERTED PRODUCTS STATISTICS[3]					
Corrugated box shipments (billion ft²)	Jan.	24.708	0.6	24.708[6]	2.6
Containerboard inventories at U.S. box plants and mills	Jan.1	2,186	−11.7		
INTERNATIONAL TRADE[2]					
U.S. paper imports (including products)	Dec.	833	−6.3	11,597	4.4
Imports of Canadian newsprint	Dec.	578	−12.8	8,269[6]	1.9
U.S. paper exports (including products)	Dec.	446	34.3	4,738	18.2
Exports of unbleached kraft linerboard	Dec.	217	43.7	2,196	21.5
Exports of woodpulp	Dec.	409	38.6	4,458	17.6
Norscan pulp inventories[4]	Jan. 31	992	−25.2		
Norscan pulp operating rates[4]	Jan.	96%	95%	97%	96%
CANADIAN STATISTICS[5] *(reported in metric tons)*					
Total newsprint shipments	Jan.	750	5.2	750[6]	5.2
Operating rates	Jan.	97%	94%	97%	97%
Inventories held by U.S. consumers	Jan. 31	1,319	−6.7		
Other paper/board shipments	Jan.	512	4.9	512	4.7
Woodpulp shipments (export only)	Jan.	610	8.3	610	8.3
Operating rates	Jan.	98%	88%	98%	88%

1. American Paper Institute. 2. API, Bureau of Census, American Pulpwood Assn. 3. Fibre Box Assn., Paperboard Packaging Council. 4. North American/Scandinavian paper-grade market pulp. 5. Canadian Pulp & Paper Assn. 6. Not annualized. (s) = Shipments.

UNCOATED FREE-SHEET: Price recovery falters

Grade structure: Uncoated free-sheet papers contain no more than 10% mechanical pulp, with the balance being chemical woodpulp. Excluded are uncoated groundwood, cotton fiber, bristols, and thin papers. Major end uses include office papers (bond, forms bond, xerographic, tablet, and envelope), printing papers (offset, cover, and text), and miscellaneous (such as technical, papeterie, or colored school).

Production/capacity: The use of uncoated free-sheet grades continued to grow in 1986, as in the two previous years. Demand was led by office copy paper, commercial printing, and book printing papers.

Shipments rose 7.7% in 1986 from 1985. Capacity rose 4.2% in 1986 from 1985, and it is expected to increase by the same amount in 1987, according to the American Paper Institute. New machines were brought online in 1986 by Georgia-Pacific Corp. in Port Hudson, La., 230,000 tpy; and Hammermill Paper Co. in Selma, Ala., 185,000 tons. Machine rebuilds and speedups added about another 63,000 tons in 1986. At the end of the year, Champion International Corp. completed the conversion of its No. 5 Stress Kraft machine in Pensacola, Fla., to 260,000 tpy of uncoated free-sheet. In addition, Boise Cascade Corp. added 35,000 to 40,000 tpy at Wallula, Wash., by adding dryer capacity to the 110,000-tpy No. 3 machine.

Domtar Inc. is planning two new machines in Windsor, Que., that will add 228,000 metric tpy by 1990, with production partly targeted at the U.S. market. Great Northern Nekoosa Corp. may add 326,000 tpy if the company follows a proposed five-year plan at three U.S. mills for machine rebuilds and possibly a new machine. Union Camp Corp. reportedly is considering a second machine for its Eastover, S.C., mill.

Outlook: Uncoated free-sheet operating rates are expected to drop slightly from 95.5% posted in 1986 to a 93% to 94% range in 1987. Strong demand growth in 1986 in part represented inventory building and came on the heels of a terrible 1985. Shipments will increase about 4% to 5.4% growth in 1987 from 1986, about double the 1987 GNP growth rate of 2.4% predicted in Blue Chip Economic Indicators.

Imports declined in 1985, but went up substantially in 1986 and should continue on a smaller rise in 1987. Prices will average 5% to 7% higher in 1987 than in 1986 if increases hold.

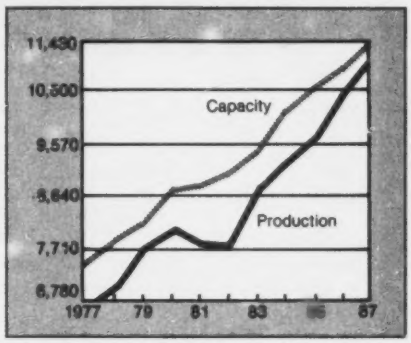
Pricing: Offset, office, and book papers all climbed in price during 1986 to near or at the levels in 1984, though some price hikes scheduled for January 1987 were partly rescinded in February. Forms bond was the first to post a major hike, with $30/ton going into effect in February. That was followed in the second quarter with increases for book papers and offset, then offset again in the last quarter. But additional capacity from Champion's Pensacola, Fla., mill was expected to help ease a tight market, and merchants reported comfortable discounting of at least 10% on the announced prices for offset. The hikes also were being undercut by producers that refused to go along.

Text and cover grades also faced trouble on the new prices, although some special cut-size papers rose $40/ton in February. Increased demand for uncoated free-sheet in 1986 may hurt demand and sales in 1987 as buyers pull back from their large orders and reduce inventories, industry sources said.

Price trends for two important grades are (year-end, $/short ton), book paper, No. 3 offset, 45-lb sheets: 1980, $785 to $813; 1981, $878; 1982, $680; 1983, $840; 1984, $880; 1985, $800; 1986, $850. Forms bond, 15-lb rolls: 1980, $643 to $697; 1981, $753; 1982, $640; 1983, $745; 1984, $680; 1985, $600; 1986, $620 to $720.

Markets: bond, mimeo, duplicating, xerographic—24.4%; forms bond—21.2%; offset printing—25.6%; envelope—8.6%; tablet—4.1%; carbonless—5.3%; other—10.8%. ■

SUPPLY/DEMAND (000 tons)



FORECAST (000 tons)

	1985	1986	1987e
Production[1]	9,750	10,504	10,673
Capacity[2]	10,515[3]	10,955[3]	11,416
Utilization rate	92.7%	95.9%	93.5%
Imports	365	452[1]	371
Exports	65	49[1]	59
Apparent U.S. consumption	10,050	10,907	11,383
lb/capita	83.93	90.26	93.65
GNP ratio	5.60	5.93	6.04

e = Estimate
1. *P & P* estimate.
2. American Paper Institute data.
3. Revised

TOP U.S. PRODUCERS (000 tpy)

	Annual capacity	Market share (%)
1. Int'l. Paper[1]	1,700	14.9
2. Champion Int'l.	1,086	9.5
3. James River[2]	834	7.3
4. Great Northern	830	7.3
5. Boise Cascade	819	7.2
6. Georgia-Pacific	798	7.0
7. Union Camp	725	6.4
8. Weyerhaeuser	580	5.0
9. Mead	435	3.8
10. P.H. Glatfelter	342	3.0

Market share of top five companies: **46.2**

Market share of top ten companies: **71.5**

Total U.S. capacity (1987): **11.4 million short tons**

1. Includes Hammermill
2. Includes Crown Zellerbach

The decision to begin with Abitibi and CIP was prompted by the logistics involved in arranging the meetings, Buchanan said, and not an indication that either company would be "instrumental in setting a pattern" for negotiation efforts. When the preliminary exchanges are complete, representatives from the union locals will aid in approving the final agendas. Formal presentations to each company were expected to take place at the end of March.

Wage increase demands, outlined during the union's Wage Policy Conference in January (P&P, Mar. 1987, p. 31), will be an essential part of each presentation. The union is asking for increases of 14.8% over the life of the new contract. Also, the union is still "very concerned" about job security provisions, according to Buchanan.

Pensions will be combined with other negotiations, rather than being covered by a separate settlement, as in the past. The most agreement covering pensions, negotiated with Abitibi in 1982, expired last fall. Pending federal legislation would institute country-wide pension reforms and could affect bargaining this year, said Buchanan. ■

EQUIPMENT

Harnischfeger rejects a $356-million buyout bid

Harnischfeger Industries Inc., which itself recently purchased Beloit Corp., rejected a $365-million tender offer for control of the company by a group of private investors. The board of Harnischfeger, based in Milwaukee, Wis., said it had no interest in pursuing the proposal. The group, led by Columbia Ventures Inc. of Miami, Fla, offered $19/share for outstanding Harnischfeger stock. Columbia already owns 7.3% of the firm's shares.

In response to the Harnischfeger rebuff, Columbia's chairman, Laurans A. Mendelson, said the investor group was studying the situation. He added that the group's position remains as stated in its filing with the Securities & Exchange Commission, which said that if the proposal was turned down, the investor group planned to "continue to explore the feasibility of, and strategies for, seeking control."

Under conditions of the original offer, current managers and plans of management would be retained. ■

SALES & EARNINGS

Canadian earnings swelled 77.7% in 1986

Healthy market pulp sales were largely responsible for the strong earnings performance by Canadian pulp and paper companies in 1986. Earnings for the full year rose by 77.7%, while sales were up 7.5%. It would have been an even better year if companies in British Columbia had not been hamstrung by the five-month-long strike by members of the International Woodworkers of America union.

As was true in the U.S., Canada's weak currency helped increase exports, particularly of market pulp. In the second half, newsprint producers reaped the benefits of their first viable price hike since April 1985, and producers are looking to implement another hike on Apr. 1 in Canada.

As Adam Zimmerman, chairman of MacMillan Bloedel Ltd., put it, "currently, the pulp and paper markets are darned good, and given stable conditions, you're going to see handsome results from them this year." Two clouds on the horizon are upcoming labor talks in eastern Canada and uncertainty in Canadian lumber markets due to the 15% export tax on softwood lumber sold to the U.S.

Tops in total sales. Abitibi-Price Inc., Canada's leader in newsprint, enjoyed a 7.1% increase in earnings on an 8.4% improvement in sales. Bernd K. Koken, president and CEO, noted that the "positive results of cost reductions, upgraded product mix, and productivity improvements were largely offset during 1986 by the negative effect on margins resulting from highly competitive markets for Abitibi's products." He predicted, however, that firming newsprint markets will continue through 1987.

MB reported sales of C$2.5 billion with a 210% increase in earnings. Third-highest with regard to total sales was Domtar Inc., which reported a 31.3% increase in earnings on an increase of 5.0% in sales.

Consolidated-Bathurst Inc. broke the C$2-billion mark in annual sales for the first time. Earnings would have been considerably above 1985 levels except for a C$54.2-million writeoff of oil and gas investments incurred in the first quarter. Con-Bath attributed the increased earnings to "improved prices in newsprint, market pulp, and linerboard, higher oper-

Canadian paper/forest products industry third-quarter results.

Companies	Full year 1986 (C$000) Sales	Change 1986/85	Earnings[1]	Change 1986/85
Abitibi-Price	$2,763,500	8.4%	$107,300	7.1%
BCFP	1,100,000	−3.5	40,200	33.6
Canfor	1,046,800	−3.4	32,000[2]	152.1
Cascades Inc.	440,130	65.3	33,777[3]	73.7
Consolidated-Bathurst	2,018,000	16.9	49,400[4]	−36.3
Crown Forest Industries	884,200	1.3	38,300[5]	130.7
Domtar	2,330,000	5.0	145,000[6]	31.3
Donohue	475,600	12.0	24,500	17.2
Great Lakes	637,531	7.7	30,049	746.5
MacMillan Bloedel	2,511,700	7.5	133,300[7]	210.7
Rolland	344,700	14.6	7,363	20.0
Scott Paper Ltd.	281,854	6.1	12,829	15.6
Weldwood	658,946	4.8	30,037	306.8
Total	$16,492,961	7.5%	$864,155	77.7%

1. Income after taxes, from continuing operations, excluding most significant nonrecurring items in both years.
2. Canfor: Year net excludes C$6.3-million writedown on shares in Versatile Corp. Cascades: 1986 earnings exclude C$10.226-million gain from tax credits and profit from subsidiary's stock issue. 1985 net earnings include C$5.294-million gain. Consolidated-Bathurst: Year net includes pretax charge of C$54.2 million related to writeoff of oil and gas investments. Crown Forest: Year includes a net loss of C$12.3 million due to combined effect of sales of Crown Stores Ltd. and loss incurred from debt restructuring. Domtar: Year net includes $10.1-million gain from prior years' tax losses in the U.S. 1985 includes a $14.3-million tax credit. MacMillan Bloedel: Year excludes C$45-million gain from sale of part interest in Koninklijke Nederlandse Papierfabrieken, Netherlands.

This Pulp and Paper special editorial report is presented under the sponsorship of The Dow Chemical Company, a leading supplier of chemicals, materials and technology to the Forest Products Industry.

QUALITY

Standards in the manufacture of U.S. paper, board, and pulp
Section I: From the converter's perspective

By KEN L. PATRICK, Editor, KENNETH E. SMITH, Executive Editor, and MICHAEL J. DUCEY, Technical Editor

Quality standards in the U.S. pulp and paper industry may be somewhat of a misnomer. Although most mills generally have some online, computerized control of their processes and utilize standardized laboratory tests to monitor and maintain quality, they do not always manufacture the same competitive products.

From the perspective of an independent box plant, linerboard quality can vary widely from mill to mill. Overall, the printability of newsprint from a twin- wire machine may be superior tc that produced on a plain fourdrinier, but other factors like basis weight and tensile strength affect press operations and could equally important to a large daily newspaper. While some mills can fill many of their customer's needs, few, if any, are able to consistently meet all of them.

This situation is not uncommon in most U.S. manufacturing industries, except in closely regulated fields, such as medical/pharmaceutical supplies and other areas involving consumer health and safety. However, in the paper industry, mill-to-mill variations in product quality do not reflect a lack of emphasis on quality control. In fact, recent process improvements and intense quality control programs implemented by several companies have dramatically boosted the end-use value of U.S.-produced paper and board.

In this special report *Pulp & Paper* takes an in-depth look at how paper mills are currently maintaining the quality of their products. The analysis begins with a series of independent converter company interviews to determine, from a customer point of view, the actual performance of paper and board grades manufactured in the U.S. Focusing on product criteria most important to these major end-users, and why, this section also examines various quality related paper and board problems encountered in the converting processes and explores how they might be solved.

Complementing these interviews is input from several major printing houses and large daily newspapers in the U.S. Together, information from these vital customer sectors sets the stage for Section II, which is a detailed, grade-by-grade survey of the paper industry itself--to determine specifically what is being done in regard to quality assurance.

Primarily, the second section of this report investigates current online and offline quality monitoring, control, and testing procedures at individual mills. A review of available and in-use equipment is also included. By combining and summarizing data, this section creates a detailed picture of the U.S. industry's effort in this most important aspect of production. By design, it reflects the strengths and weaknesses of a "system" which has evolved according to changing market conditions, end-user requirements, and developing technology.

The third section examines new approaches to quality control that have been implemented only in the past year or so. One such method, statistical quality control (SQC), is studied from the perspective of several vanguard mills that have significantly reduced process and finished product variations with programs customized to their operations. As discussed in this report, many of these mills are now requiring their raw material suppliers to initiate SQC programs of their own.

A glossary of major tests and testing terminology follows this final

Photograph by Rod Reilly

Measuring moisture profile across paper machine width at Georgia-Pacific's Port Hudson, La., paper mill.

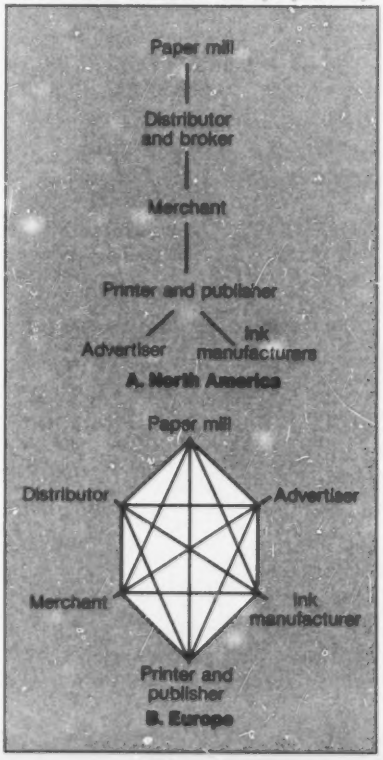
section. It is not intended to be a complete dictionary of laboratory test procedures and equipment and is included only to familiarize readers with terms related to the text of this report.

U.S. VS EUROPEAN TRENDS. Due to a combination of resource and weak currency advantages, the U.S. paper and paperboard industry was able to firm up its position as low-cost commodity producer in the world marketplace during the 1970s. However, some industry analysts feel that this financially successful emphasis on cost-minimizing, together with a trend toward forward integration into converting by the paper and board producers, has detrimentally affected converted product development in recent years, placing U.S. companies, both independent converters and paper companies with integrated converting operations, in a competitively weak position compared with their western European counterparts.

In an interview with *Pulp & Paper*, and an article published in *Tappi Journal* (Oct. 1986, p. 39), Peter Woodbridge, vice president of marketing and sales, Woodbridge, Reed & Associates, a division of H.A. Simons (International) Ltd., pointed out that as paper and board products have become higher valued and more sophisticated in the 1980s and product life has shortened, commodity growth has slowed significantly. At the same time, the quality and performance of those products have become increasingly important. In the European arena where less emphasis has been placed on minimizing costs, converters have been able to develop improved products and gain a competitive edge over American converters.

Tissue and absorbent products, according to Woodbridge, may be the only converting sector where the U.S. still maintains world leadership. This he attributes to the direct contact and rapport U.S. companies continue to have mith these markets and to the fact that tissue producers have effectively controlled the converting end, including even the design and development of equipment used in the converting operations. In this highly competitive area, the interest and involvement maintained by the tissue and nonwovens manufacturers in converting operations have kept cost-minimizing pressures somewhat in check.

FIGURE 1: **Comparison of relationships between printing paper producers and converting segments in the U.S. (top) versus those in western Europe (bottom).**



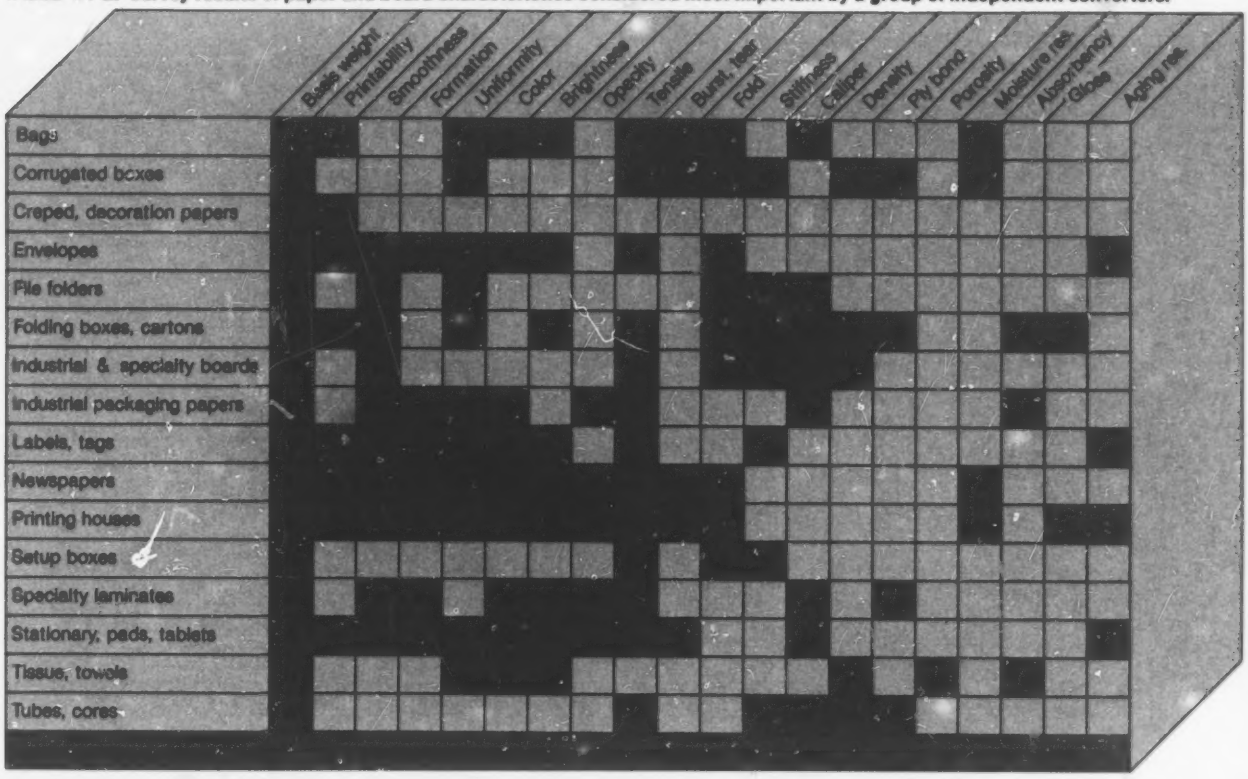
But in the paper and paperboard sectors, the U.S. has clearly relinquished its leadership role, "primarily due to a lack of converting innovation and the converter's shift away from being market-oriented toward being cost-oriented," Woodbridge emphasized. "In the 1950s and 1960s, paperboard and packaging converters in the U.S. were the most innovative in the world. But the forward integration of paperboard producers, who were much more conscious of cost-minimizing than were independent converters, has resulted in a distinct trend away from product development."

As the U.S. dollar strengthened in the mid-1980s, the American companies position as low-cost commodity producers was suddenly eroded. In the wake, insufficient time and money had been spent on R&D to develop converted products competitive with those being produced in western Europe. As a result, considerable converting technology is now being imported into the U.S.

The overall quality of printing papers produced in western Europe is generally superior to that of U.S. papers, according to Woodbridge, which, together with a shift in currency values, helps explain the increased importation of these European grades into the U.S. To a large degree, this superiority is because European producers "have much better contact with printers, publishers, machinery producers, ink suppliers, and advertisers—the industries that directly affect conversion," he explained. This close relationship between the producer and converter "leads to a more market-oriented business approach."

Figure 1 compares the relationships between printing paper producers and various converting elements in the U.S. with those in western Europe. Woodbridge pointed out that European converters are treated more as "peers" or even partners in some respects, whereas

TABLE 1: ***P&P*** **survey results of paper and board characteristics considered most important by a group of independent converters.**



in the U.S., the relationship is very linear and rigid, subordinating the converter in certain respects. As depicted in the figure, the complex, sophisticated European network is more conducive to market feedback, allowing interaction in many directions resulting in improved product innovation and performance. In the U.S., the linear setup is "designed basically to sell commodities."

Although Figure 1 refers to printing papers, it conceptually applies to all paper and paperboard sectors. The "pendulum," in Woodbridge's view, "has swung and many U.S. pulp and paper companies are now paying for a lack of foresight." It should be noted that the value of the U.S. dollar has declined significantly against foreign currencies in recent months, but whether or not the pendulum may swing again is, at this time, still a matter of speculation.

The following section, based on a *Pulp & Paper* survey of 50 independent paper and board converter companies in the U.S., examines quality criteria most important for a cross-section of products and operations. It explores the needs and opinions of these converters in relation to product development and manufacturing technology in the U.S. It examines what could be done to produce higher valued products that will be more competitive in the world market. Concerns about pricing, relations with paper mills, producer/converter feedback, etc., are also examined.

QUALITY CRITERIA. Table 1 contains paper and board characteristics considered most important by independent converters responding to the survey. Company products are listed by the converters, and only those paper and board characteristics specifically cited are included.

This table summarizes and combines data, i.e., not every manufacturer of a certain product chose the same characteristics, but every company's response is included. Thus, the table may not represent a consensus of opinion. Not all newspapers, for example, thought that folding endurance was important, but at least one did. Likewise, only a few label and tag converters listed aging resistance as important. Not all converters felt that basis weight was important but at least one converter for each product listed it.

Most comments regarding converter quality criteria came from newspapers and printing houses. Richmond Newspapers, for instance, reported that factors affecting runability are the major considerations given newsprint they buy, adding that "this is necessary due to the converted offset printing process we use. The introduction of water and fountain solution to printing requires a strong sheet that can withstand the moisture. The converted

press exposes the newsprint web to more moisture than the conventional offset, creating additional moisture requirements.

"The water drop test is necessary for us to determine adequate moisture resistance. It is done by placing a measured drop of distilled water onto a suspended newsprint sample and with a stopwatch, timing the drop until complete absorption," a Richmond spokesman said.

In Minnesota, a large web offset printing facility divided important printing paper characteristics into these two categories— printability and runability. The quality control person at this plant explained "at this point, I don't believe it is known what characteristics of paper are the most important as far as printability is concerned. In the past many tests have been performed by paper mills to help produce a better product. But the ultimate test is the web test.

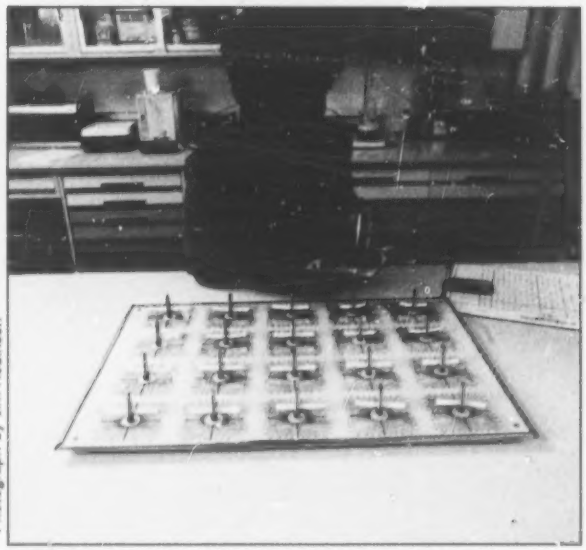
"The problem for paper mills has been to get quantifiable feedback from the printer as to how the paper prints. In this respect, our facility is now able to provide excellent feedback from print quality numbers we are collecting from our printing presses. Currently, we are conducting our own tests for smoothness, brightness, moisture resistance, surface formation, color, gloss, etc. And we share this information along with print quality data with our paper suppliers on a monthly basis. We hope this data will help the mills make a better product.

"Another advantage of collecting print quality data is to be able to change or adjust press variables according to the type of stock. Printability characteristics are more critical to the final product than the runability characteristics, but neither can be forgotten.

"Runability characteristics such as strength, stiffness, creaseability, stretch, burst, tear, and fold determine if a web will run on a press without breaking and produce a good folded product. Some characteristics may not affect runability or printability, such as opacity and color. However, the customers usually choose the color they like or the amount of show-through they will accept. Many customers have elected to run a lower basis weight stock due to costs rather than quality. We feel that we have to know how to adjust to print well on all kinds of stock," he explained.

Hart Press, another large Minnesota printing house, specified that the coated groundwood papers it uses must have good roll quality and minimum mill splices, adding that it records web breaks per 100 rolls on all of its stocks. Quality and shade must be consistent from run to run and month to month because Hart's customers demand extremely high consistency. Coating must be of the highest quality—no scale, streaks, uneven gloss, mottling, etc.

Cox Enterprises, publishers of the *Atlanta Journal* and *Atlanta Constitution*, stated that their most important characteristics today are opacity and printability, although brightness and/or color are becoming important and will increase in importance in the years ahead. The *Dallas Morning News* also listed runability factors as being extremely important, along with brightness, basis weight, opacity, and smoothness.



Photograph by Jim Robinson

Testing paper curl at G-P's, Port Hudson, La., paper mill.

QUALITY PROBLEMS. Figure 2 shows responses to questions on overall quality of shipments received by converters, off-spec shipments, and pricing. Response levels vary for these questions because some companies did not answer all of them.

Of particular interest, about three times as many converters said that they regularly received sufficient quality paper and board than those who said they did not. When the "sometimes" responses are considered with the "yes" responses, the independent converters give producers very high marks on the general quality of paper and paperboard they buy.

Although responses were favorable on the quality question, the comments were somewhat mixed. Zimmer Paper Products, an Indianapolis, Ind., based converter of food and confectionary packaging, and release-coated papers for industrial applications and laminated pressure sensitive basestock for labels, said that although quality from U.S. producers is generally sufficient, "domestic papers are much in need of improvement. Formation of European sheets is much better than that of U.S. grades, and this provides superiority in all of the other characteristics." Zimmer mainly buys paperstocks from midwestern mills and Europe.

San Joaquin Packaging Corp. of Stockton, Calif., buys some 850 tons of board per month for conversion into folding cartons. Most of the recycled board, bought from local mills in California, reportedly has too much moisture and other variations, and the printing surface is "inferior." Solid bleached sulfate SBS board from Idaho and Georgia mills

is "adequate." Cindus Corp., a Cincinnati, Ohio, creped paper manufacturer for decorations, insulation, and industrial wrapping, said that electrical grade kraft (northeastern mills) and tissue (midwestern mills) are adequate. However,the 4,000 to 5,000 tpy of kraft purchased from southern mills is not. "What we get instead of converting kraft is modified multi-wall sack grade. It is dirty, has bad formation, and is inconsistent," the company explained.

Plymouth Inc., Bellmawr, N.J., a tablet, pad, and envelope manufacturer purchases "sufficient quality" stocks directly from P.H. Glatfelter Co., International Paper Co., and Georgia-Pacific Corp. mills. "However, in the past, when we bought from paper merchants (especially envelope papers), we had some difficulties. The paper would jam up in the machinery regularly. But we always buy our tag stock from merchants and we seldom have any problems," a Plymouth spokesman added. Princeton Packaging, a Vernon, Calif., grocery bag converter reported that it did not receive sufficient quality stock, explaining that "consistency between and within mills (on the West Coast) is not satisfactory."

The Columbia Corp., Chatham, N.Y., manufactures a laminated specialty board (displays, jigsaw puzzles, book covers, etc.). Board bought from mills in New York and paper from mills in the Northeast and Midwest have "yes" and "no" quality. Uniformity of shade in colored papers from run to run is sometimes a problem. At times, appearance is a problem because of specks, slime spots, and holes or undefibered stock in a portion of a run. Crowell Corp., Newport, Del., reported that the kraft paper it buys from mills throughout the U.S. to make sealing tapes and other specialty products generally has some uniformity problems with the heavyweight grades. Constant splicing problems are also experienced when coating the sheet.

Fortifiber Corp., Attleboro, Mass., manufactures wide laminated and coated products for industrial uses. Stocks bought from various regions of the country include southern and western converting kraft and southern kraft linerboard. A plant spokesman reported that "in general, the natural converting kraft is not of sufficient quality because of severe bagginess on wide-width (up to 100 in.) rolls." John T. Raisin Corp., a foil and metalized paperboard converter in South San Francisco, Calif., is not satisfied with the quality of board it purchases because of a consistently "rough surface."

OFF-SPEC SHIPMENTS. The majority of converters are satisfied with the overall quality of paper and board products they buy, however, an overwhelming number reported regular receipts of off-spec shipments, as is shown in the middle graph of Figure 2. Obviously, most converters consider out-of-specification problems separate from general quality problems. Most would classify these as abnormal, one-of-a-kind defects or orders not as they specified, but otherwise of apparently acceptable quality.

Some converters purposely buy off-spec paper and board, such as Damsky Paper Co. of Birmingham, Ala. (industrial papers), and Paxton Paper Co. of Harrisburg, Pa. (file folders). "We specialize in buying and selling off-spec merchandise," Damsky stated, and according to Paxton, "we actively pursue job lot markets." John T. Raisin Corp. said "we do receive and try to use off-spec board."

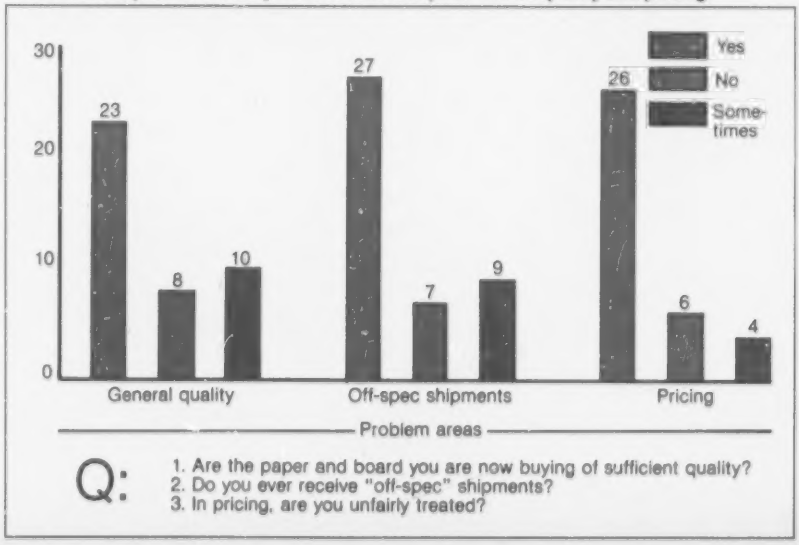
For most converters, however, off-spec shipments cause serious

TABLE 2: **Top 10 recommendations to U.S. paper mills from surveyed converters.**

Converter Suggestions
1. Improve overall consistency
2. Increase quality control efforts
3. Make basis weights more accurate, uniform
4. Improve printability
5. Enhance smoothness and general surface formation
6. Cut slitting/rewinding defects
7. Bleach to a more uniform brightness
8. Control moisture, caliper, coating variations
9. Reduce pin holes, shives, wrinkles
10. Provide more technical help

Q: As far as your converted products are concerned, what could paper mills do to make better paper or board?

FIGURE 2: **Response of surveyed converters to questions on quality and pricing.**



problems. According to Colombia Corp., "we try to avoid them by requesting out-turn samples, but these do not always represent the whole run. When we do run into off-spec paper, not only do we lose product, but we also experience downtime since we then must pull another roll from stock."

Zimmer Paper Products reported that they did receive off-spec shipments "but not as frequently as in the past, thanks to our vendor certification program. Advance out-turn samples and mill run data head off some potential off-spec shipments. We try to find a home for off-spec materials that slip through, in order to minimize economic loss to the supplier, but this becomes more difficult as our customers' quality demands are constantly increasing."

Waldorf Corp., a St. Paul, Minn., folding carton converter, stated that "with off-spec shipments we do receive from time to time (quality specs off of what was specified), major problems generally involve delamination, caliper, and weight." Waldorf buys 68,000 tpy of SBS and solid unbleached sulfate SUS paperboard from a variety of southern mills and uses about 80,000 tpy of recycled board, a large portion of which Waldorf produces.

Universal Folding Box Co., Hoboken, N.J., also reports delamination problems with some of its receipts, as well as sheet waviness or curl, and flaking of the coating. Converting Specialties, a Dayton, Ohio, board and paper sheeting operation, uses stocks (International Paper Co., Manville Corp., Westvaco Corp., and Miami Paper Corp.) purchased and shipped to its plant by customers. "We do receive off-spec shipments which causes us too much downtime. This happens infrequently, and when it is brought to the supplier mill's attention, the roll is quickly replaced or credited to our customers," a representative pointed out.

Wrinkles and holes are also a persistent problem, as reported by Fortifiber and Chase Bag Co. (multiwall and consumer) of Sibley, Iowa. Fortifiber added that "we find this to be at too high a frequency in natural kraft and linerboard, resulting in increased waste in the converting operation." Orchard Corp., St. Louis, Mo., tries to use off-spec shipments whenever possible in its roto-gravure printing operation for industrial end-use products, but it does "warn suppliers to correct specs." Sanitor Mfg. Co., Kalamazoo, Mich., always "sends back" the off-spec toweling or tissue it receives.

The converting division of Unijax Inc., in Jacksonville, Fla., manufactures precision sheeting, file folders, add roll, and envelopes (stock purchased from Union Camp Corp., International Paper Co., Georgia-Pacific Corp., and Gilman Paper Co.). The plant stated, "we have challanged one mill for running consistently over nominal basis weight, representing an effective, significant price increase. We do not accept a response that rolls are 'within tolerance.' We demand the entire mill cross-section be at nominal."

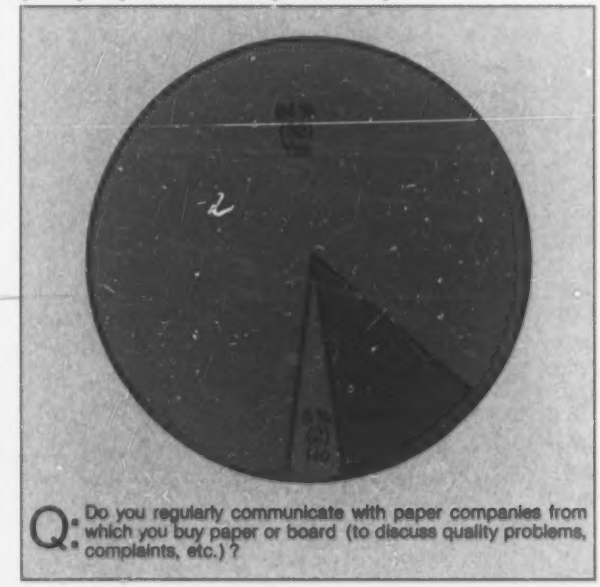
Richmond Newspapers explained that it attempts to use off-spec material after lodging a quality protest with the vendor, adding that "it usually involves the water resistance of the sheet. However, recently the regularity of this problem has diminished. It causes additional running breaks that otherwise would not have occurred. This leads to reduced production and a greater amount of waste."

A Midwest printing house pointed out that it does not discover off-spec paper until it is on the press or after press. "Pretesting paper means opening rolls to cut out a sample. This is a time-consuming and wasteful process. In order to do our paper testing, we sample the stock left on the core after it is taken off of press. Runability problems are recorded on press and fed back to the paper mill. If rolls are found to be substandard while running on press, they are taken off and set aside to be returned to the mill or scrapped," a spokeman emphasized.

PRICING CONCERNS. The pricing graph in Figure 2 shows that many converters continue to be concerned about the subject of pricing. Even though not directly related to quality, pricing obviously has an effect on a converter's end product. If necessary, some of the quality may have to be sacrificed when prices escalate, to maintain a certain level of profitability.

Comments generally focused on insufficient lead time when price hikes are announced and what independent converters see as "price volatility" in the industry. A representative from Fortifiber said that "the major paper companies need to develop a great deal more stability on paper and board pricing. The companies are very slow

FIGURE 3: **Level of converter/paper company communications (survey responses shown in parentheses).**


Q. Do you regularly communicate with paper companies from which you buy paper or board (to discuss quality problems, complaints, etc.)?

Testing filter paper at James River's filtration products technical lab in Richmond, Va.

to grant discounts to small converters. However, as soon as a general increase is posted, they are very quick to implement it to all size operations. But, generally, I feel that we are fairly treated."

Zimmer Paper Products stated that "price volatility has been a problem for us, especially when pricing takes off on upward spirals that seem to have little to do with traditional economic models. We realize that the paper mills are then subject to the same pressures that they impose on us and for the same reasons—material costs represent a very high percentage of our selling prices. We do not feel that we are unfairly treated by the mills, per se, although it sometimes seems we are put at a disadvantage by the pricing policies of mill-owned converters.

"This disadvantage is not, we believe, because we pay more for the raw paper but because captive converters are not required to generate the machine-hour returns that keep independent converters in business (witness the declining numbers of the latter). In some cases, this practice of 'giving away' the converting processes is a means of guaranteeing tonnage on paper machines. In other cases, it may reflect the ascendant importance of cash flow over profit margin in the financial circumstances of certain large corporations," a Zimmer official explained.

The Atlanta Journal and *Atlanta Constitution* explained that "newsprint pricing, for years, has been greatly influenced by the Canadian paper companies which continue to supply more than 60% of all newsprint consumed in the U.S. Most U.S. producers follow the pricing lead of the Canadians," a Cox Enterprises official pointed out, adding that "newsprint is a significant part of the total cost of producing a newspaper, and no publisher likes a system where the supplier seems to adjust product prices at will. As more newsprint is now being purchased by a growing number of group newspaper owners, including Cox Enterprises, there is a greater balance of pricing power today than in the past. Hopefully, the big Canadian producers will learn to deal with large buyers on a more business-like basis that includes negotiation of paper prices rather than a continuation with the 'announced price' system," he emphasized.

Princeton Packaging said that it is difficult to get timely increases from end-users, adding that "mills don't always plan or communicate price changes in order to help independent converters recover those additional costs." Another Fortifiber plant in Tracy, Calif., a laminating, coating, and reinforcing paper operation, felt that the independent converters "should have at least 30 full days on price increases and that orders accepted before perhaps 45 days be at the old price. We cannot easily pass these increases along without proper notice," a spokesman for that plant emphasized.

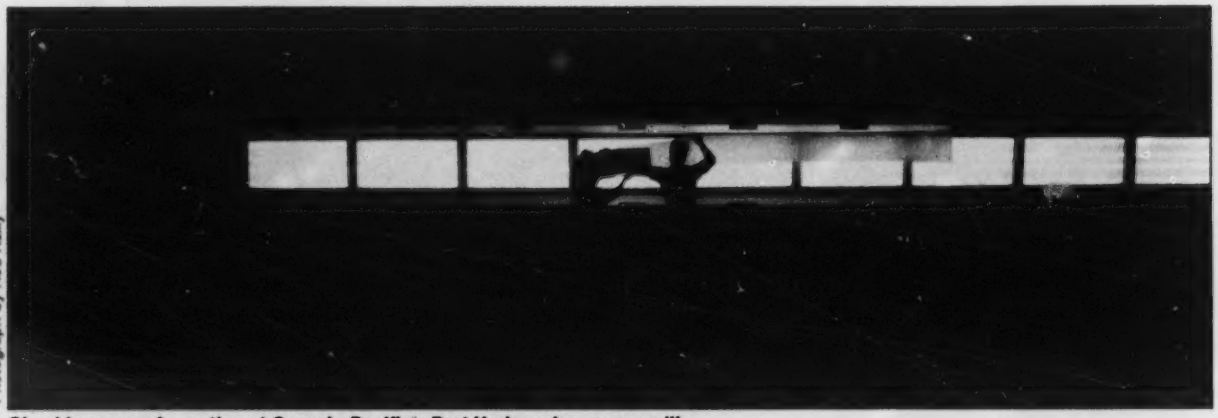
According to Waldorf, "as a converter, many times we see a mill not plugged in as to actual domestic market conditions but looking at factors not directly linked to domestic paperboard, i.e., the demand of pulp markets worldwide." John T. Raisin Corp. pointed to problems on the West Coast caused by apparent price variations in the rest of the country. "There needs to be more uniform pricing throughout the U.S., and paper merchants should be eliminated—they are not well informed on technical problems," a company official said.

Damsky Paper Co. stated that, "generally, we are fairly treated because when prices get too far out of line, we can no longer deal with a source. Over the long run, costs seem to average out." Columbia Corp. expressed the opinion that, with the exception of a few specialty-type grades, paper and board are usually priced to meet market conditions. "We have no particular problems with prices, but we could probably get somewhat lower prices if our business warranted larger purchases," a spokesman stated.

COMMUNICATIONS. Most (84%) of the respondents reported that they do have regular communications with their suppliers regarding problems, needs, etc., as illustrated by Figure 3. Of the 38 converters who answered the question, only two (5%) said they had no contact at all. The people converters report to be most frequently in contact with at the mills are (in order of frequency):

1. Sales staff (40%)
2. Technical reps. (23%)
3. Quality control (17%)
4. Plant manager (13%)
5. Production (07%)

Methods and procedures of communicating with producers vary. Some use photographs to show specific problems with shipments, such as Williams Paper Co. of St. Louis, Mo., (paperboard boxes). This is backed up with an immediate phone call "while everything is still fresh in the memory." General Box Co. of Waycross, Ga., reports regular communications with a very high level of cooperation and exchange, but Orchard Corp. gets a "very slow response as a general rule."



Photograph by Rod Reilly

Checking paper formation at Georgia-Pacific's Port Hudson, La., paper mill.

According to Zimmer Paper Products, "We have close and regular communications at various levels with most vendors, consisting of a vendor certification program which provides advance quality control data, documentation to vendors of every complaint (whether a claim is involved or for information only), regular meetings with sales, technical support, and product managers of supplier mills, and attendance by a delegation of our executives at American Paper Institute's Paper Week to meet with top paper company managers."

Cindus Corp. reported that if their supplier company is small, they can deal directly with manufacturing. But, large paper mills will "force the quality problems through their sales department." A company official added,"this does not work when you are trying to buy special grades. With standard grades, you take what you get. But we need direct communications when we are buying special grades."

Fortifiber, Attleboro, explained that with specialty krafts it buys, "suppliers are very sensitive to the performance of their material on our converting equipment. But, this is not the case with converting kraft/linerboard suppliers who are not responsive to quality complaints about the runability or uniformity of rolls they supply."

On the newspaper side, Richmond Newspapers sometimes communicates through the vendor sales staff. However, it pointed out that most vendors have technical personnel who visit or call at regular intervals. Problems are acted on quickly and with open communications, a spokesman emphasized. The *Atlanta Journal* and *Constitution* has regular, ongoing dialogue between its various production departments and technical representatives of various paper companies they do business with. "Problems arise, but we always receive courteous and prompt attention when they do," an official said. The *Dallas Morning News* communicates on a "regular basis" with its suppliers, at least monthly, in both written and verbal forms.

John T. Raisin said emphatically that most paper companies are not interested "in problems of small users, and their sales people are not well informed on handling quality problems." Chase Bag Co. added that its communications are mainly limited to filing claims for defects.

In response to a question on what paper companies could or should do to better improve relations with their customers, the following comments were most frequent:

- Pay closer attention to delivery dates—keep commitments
- Provide more and better technical assistance in the field
- Give better, faster followup on complaints
- Keep customers better informed on pricing and supply situations
- Sell direct—avoid using paper merchants
- Make greater effort to understand customers' processes.

In response to a question on how mills could help converters improve their products, some typical responses included:

- Improve the product consistency and roll uniformity
- Adjust moisture content for regional and seasonal variations
- Make better roll splices
- Eliminate pin holes, wrinkles
- Concentrate on meeting specifications established by the customers and mills
- Help prevent roll damage with better protective coverings, etc.
- Do not ship questionable or suspect rolls
- Improve smoothness and basis weight
- Minimize contaminants
- Emulate Europe and Japan.

Of the converter companies surveyed, 60% receive shipments by truck, 15% by rail, and 25% by a combination of both. Of the companies using trucks, approximately 25% owned their own. Types of shipping damage reported include: crushed rolls, smashed cores, moisture damage, flat rolls, bruised rolls, and lap damage from forklift or clamp trucks. Much of the damage was attributed to load shifts, with some converters experiencing more damage with rail shipments than by truck.

SECTION II:
CURRENT MILL TECHNIQUES, PRACTICES

In today's international pulp, paper, and paperboard markets, quality assurance is absolutely essential if mills are to compete under both adverse and fortunate readings of the economic barometer. Particularly in the past five to seven years, many mills have taken tremendous strides in the quality control area, installing the latest equipment and initiating some innovative new programs. The technological advances made in electronics, in particular have helped paper producers establish stability in product quality through the development of advanced online and offline measurement devices.

Paper products have evolved to a point where physical and optical properties have to be solid, reflecting the many demands of the converter and printer. Equipment and chemicals have been used to enhance certain end-use properties of some grades. But the majority have had to be "straightened out" by drastically reducing all variations and making product uniformity the key to garnering repeat orders and to gaining access to expanding and new markets.

IMPACT ON PRODUCT. In an effort to determine the extent of current online and offline testing being done in the U.S. industry, *Pulp & Paper* randomly surveyed some 50 pulp, paper, and board mills. Comments from manufacturers of each individual paper and paperboard grade were obtained to identify the impact of online testing and other programs to make a better and more uniform product.

Data in Tables 1 through 4 represent a grade-by-grade sampling of responses from all regions in the U.S. across most paper grades. Table 1 covers linerboard and corrugating medium; Table 2 shows typical properties of coated grades. Table 3 includes uncoated grades; tissue, and newsprint; and Table 4 compares brightness targets for most grades. The following sections incorporate comments from the quality control personnel interviewed at key mills.

TABLE 1: **Targets and ranges for basic measurements in many mills producing brown grades.**

Linerboard	Property	Chief method	Target range
69 lb	Moisture	(online)	6.5 ±0.5%
	Basis weight	(online)	69 ±1.5 lb
	Surface	S & S Scuff	50 ±5 rev (or strokes)
	Internal bond	Scott	70 +10 min
	Crush	Ring	110 ±10 psi
	Burst	Mullen	130 ±5 psi
	Brightness	ISO	15 ±2%
	Absorption		NM
42 lb	Moisture	(online)	5.6 ±0.2%
	Basis weight	(online)	42 ±0.5
	Surface	S & S Scuff	40 ±12 rev
	Crush	Ring	70 ±5 lb
	Burst	Mullen	100 ±5 psi
	Brightness	ISO	16.5 ±2%
33 lb	Moisture	(online)	6 ±0.2%
	Burst	Mullen	80 ±5 psi
	Brightness	ISO	15 ±2%
Corrugating medium			
26 lb	Moisture	(online)	6.5 ±0.5%
	Basis weight	(online)	26 ±0.3 lb
	Crush	Ring	60 ±10 lb
	Absorption	Water drop	3 ±1 sec

SBS GRADES. "Specifications for the product have not changed that much. The end-users have been concerned mostly with printability and graphics capabilities. We, like most manufacturers, will match the product to the end-user. The only real change has been the determination to make paper uniform from reel-to-reel and improve cross-directional uniformity," one mill said.

According to this major producer of solid bleached sulfate (SBS board, "converters are now running at higher speeds and their tolerances have become much tighter. They are less able to tolerate any variation in a specification within every reel. The challenge comes in identifying each customer's critical variables during production. Online gauges have been a blessing, capable of quick evaluation and resolution, enabling the producer to evaluate each reel (with customer's needs in mind) while it's building. When identification and evaluation are complete, performance can be determined."

LINERBOARD. In our study, producers of brown papers documented staggering improvements in profiling (100% to 200% variation reductions were not uncommon). These products are evolving in two directions: one value added (preprint, toplined, mottle) where quality is very important, and the other emphasizing cheaper construction but with strength and performance being equally critical. Producers of both have installed the equipment, and many have increased moisture levels and boosted production. The same is true for many corrugating

medium producers. Table 1 illustrates the targets and ranges for the basic measurements occurring in many mills producing brown grades.

One mill reported that "being a preferred supplier for customers has been a goal in our mill improvements. Installing a profiling control system was one successful step in achieving that goal. Since the system went up, the basis weight profiles have been flat, moisture in the sheet has risen more than a half-percent, and production has increased. The streaks were cut by 40%"

NEWSPRINT. "The twin-wire former deserves much credit for improving the quality of newsprint, such as two-sidedness," one mill emphasized. "When planning our machine improvements, we knew profiling equipment had to be included to keep us competitive in the local market. The communities that are growing rapidly are the same ones that want more colorful and attractive newspapers, and publishers have responded by only accepting products from mills they feel are going to deliver a quality, consistent product in every roll. The profiling control system has reduced moisture variation by 70%, caliper variation by 75%, and basis weight variation by more than 60%."

TISSUE. "The increase in production is what made the front office happy," one mill said about its profiling equipment upgrade, "but it was the peak-to-peak variation that has made the difference. Tissue grades can be tricky to produce and machine breaks are sometimes precarious. The same can be said for the converting end. Yes, we make 10% more paper, but the range from target specs has gone down more than 50%."

"Many of the quality pressures associated with tissue products concern its decorative features, such as shade and pattern," another tissue mill reported. "Not even absorbency is emphasized anymore. But among converting managers, product uniformity is of the utmost importance. When cutting, rolling, printing, etc., the converter must be assured that a slight change in any of the process variables will not interrupt the production run. We now ship products that have less than 2% variation in any critical parameter. Our new profiling equipment has allowed us to speed up our yankee by 10%, and it has adjusted very well."

PRINTING, WRITING GRADES. The biggest push in quality assurance and improvement has come from the uncoated and coated paper grade sectors. These grades are the most widely tested and scrutinized in the industry, causing extreme selectivity among tough-to-please end-users.

Technological advances, primarily involving chemistry, have been key factors in developing better printing and writing papers capable of meeting progressively more stringent end-user requirements. New chemicals for internal bonding, coating, and other uses have produced products with many improvements in physical and optical properties.

Equipment suppliers have been actively pursuing printing and writ-

TABLE 2: **Typical properties of coated publication grades.**

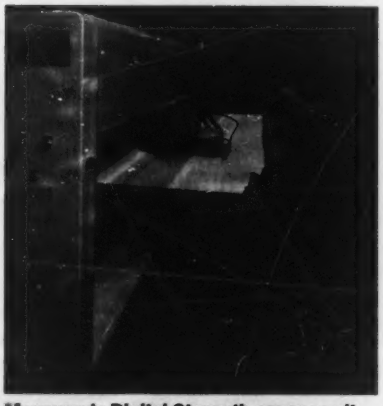
General characteristics	Typical use	Basestock	Coating	Brightness	Gloss range	% increase 1982-87	Sheffield smoothness
No. 1 Enameled, double-coated, hand-sorted, expensive base and coating; high gloss; basis weight above 70 lb	Annual reports	High-brightness chemical pulp; heavily filled	High in TiO_2, high brightness clay, synthetics	82-86	<70	10-12	37-40
No. 2 Double-coated, expensive base and coating	Expensive advertising	High-brightness chemical pulp; filled (clay)	High in TiO_2, some clay; expensive synthetics & binders	78-82	66-70	15+	35-40
No. 3 Single- or double-coated, lower-quality basesheet	Advertising	Chemical pulp; minor amounts of groundwood	Mostly clay, some TiO_2, various binders	76-82	65-67	10-15	35-37
No. 4 Lower cost, lower brightness	Magazine	Groundwood and chemical pulp, some clay filler	Lower brightness clay, small amount TiO_2, cheaper binders	72-78	56-60	10	30-35
No. 5 Lower basis weight, high groundwood content	Directories, catalogs, magazines	Mostly groundwood or TMP, chemical pulp for runability	Lower brightness clay, cheaper binders	68-72	>56	10	30-35

ing paper producers, and they have been very successful in selling more sophisticated equipment. Many of the new online scanning packages are targeted for this market. Probably the greatest demand has been for instruments that continuously monitor gloss characteristics. Another piece of equipment, with a significant effect on overall quality of coated printing and writing grades, is the short-dwell coater. Production increases have been realized with this development, along with quality improvements and efficiency gains, explaining its widespread acceptance in the industry.

Printing technology has accelerated rapidly in recent years, being quickly accepted and implemented. In some areas of the country, foreign grades have been bought by printers and converters needing paper with superior performance and appearance characteristics. The domestic market has now reacted to this challenge. With the falling dollar, competition has increased and exports are flattening (especially in the coated area). End-users of these grades have persistently pressured producers to improve specifications, and based on comments from paper companies surveyed, some customers may require even higher appearance and performance from the top coated grades. But for now, many end-user segments appear to be satisfied.

In our survey, both small and large producers of coated paper were contacted to identify the upward shifts in gloss and smoothness. For the larger producers, efforts to improve these vital characteristics began about three years ago when foreign products seriously entered the domestic scene and end-users began buying these then-cheaper goods. Domestic manufacturers countered by employing innovative coating formulations and upgrading calendering equipment to boost the quality of their products. As a result, gloss (TAPPI) and smoothness values rose by 10% or better across all coated paper grades (Table 2).

These improvements can be directly attributed to coating formulations involving binders that help boost surface strength, printability, and appearance characteristics of coated paper. In this regard, the following analysis focuses on enamel grade finishes. However, the performance and appearance of dull and matte finished grades have been similarly improved using many of the same adaptations.



Measurex's Digital Strength sensor as it measures strength properties for Longview Fibre's specialty kraft paper.

The most widely used binder has always been starch due to its price, availability, and, until the mid-1980s, acceptable performance in converting and printing processes. The demands for paper with reduced picking and mottling in four-color offset printing have increased tremendously during the past five years, and chemical suppliers have been at the forefront in providing new components (for old formulations) to help solve these problems.

In using starch, it has been said that binder migration occurs at a certain solids content and is due to evaporation rates where dewatering of the basestock or coating layer is too rapid. This can be reduced by uniform dewatering of the basestock, producing an even surface (one that is not as susceptible to migration of a less sophisticated coating formulation during coat drying). But, components such as SB-latex, CMC-latex, proteins, etc., have proved to be more effective in stifling migration, thus lowering mottling in offset printing.

Binders can both open and close pores of the paper surface, depending on the formulation and coating conditions. Porosity must be evenly balanced with gloss, and herein lies the complications of formulating an ideal coating for wood-free and wood-containing papers. The coat weight variations caused by equipment and chemicals will also cause a variation from ideal or lab produced targets. Strictly from a formulations standpoint, sole binder systems, particularly cheaper ones, are acutely sensitive to variations in coating and forward processing of coated paper. The addition of co-binders to improve retention, surface, and appearance have been used to help obtain a balance between end-use specifications and the existing coating process.

The surest way to avoid mottling is to produce a uniform basestock (discussed in the online testing section below). But short of that, porosity of the printing surface can be adjusted through chemistry. An increase in solids content, maintaining heterogeneity, is one viable solution. For this, calcium carbonate, SB-latex, PVOH, and soya protein have proven capabilities. Published data have shown that as the solids content increases (and the coat weight decreases), Bekk porosity decreases, while K&N values and IGT pick values approach acceptable levels for a given formula, process, and end-use. Mottle improves appreciably as well. This can be shown through methods utilizing the time between inking and subsequent wiping, where a host of intervals, apparati, and samples are also employed, making it difficult to summarize data.

Sentrol's new housing design for online measurement devices.

Increasing the binder will increase pick resistance but will lower porosity, which may adversely affect mottle. Therefore, uniform distribution of the binder system is imperative for suitable cohesion of the coating layer, especially when a sole binder is used. Combinations of starch, latex, and protein have given marketable results in many parameters that can eventually influence print mottle.

Interestingly, these developments apparently began in the East and are now reaching the West. In smaller mills, similar measures were taken to solidify certain specialized market niches. In testing, some mills are now using the Parker Print-Surf test in combination with Sheffield and/or Bendsten smoothness to acquire more information on the finished product. Set targets for Parker Print-Surf are greater than seven (units) for coated stock, indicating that characteristics for the printing surface have improved.

MARKET PULP. Exporters are often the most concerned market pulp producers and, therefore, are very involved in the quality specifications. Recent process changes in the market pulp sector incorporate both equipment and chemicals, and the benefits are integrated in product quality and production cost.

"When planning a recent upgrade project, fiber quality was our top issue," a modern market pulp mill explained. "What could we expect from local timber resources and how would our pulp compare with that of domestic and foreign producers?

"The first thing we realized was that our dirt count would be low due to the dominant amount of roundwood used. It was important to size the barking drums to retain a maximum percentage of bark. The double-screening of chips and the four-stage cleaning was necessary to meet our cleanliness goals. As a result, our shive count is extremely low. In the pulping process, we put in the proven technologies for production of good, strong pulp. We substitute chlorine dioxide in our chlorination stage, use countercurrent washing with filtrates, and use anti-chlor chemicals before high-density storage. Our pulps compare nicely with those produced in northern Europe in properties such as tear, burst, and tensile. The brightness target is 90% ISO, and production of off-spec product since full startup has been negligible."

Table 4 is from *Pulp & Paper*'s annual bleaching survey database. Brightness is taken a few different ways and no conversion factor has been set, making it difficult to generalize the results. It has been even more difficult to compare brightness values with chemical consumption. The data presented here provide only a general picture of brightness targets among most grades.

LATEST ONLINE ADVANCES. A major factor behind most quality assurance improvements in recent years has been the development and installation of online measurement devices that analyze and respond to critical variables during web formation. In the early days of online testing, the instruments were there primarily to facilitate process control rather than assure quality. Now they do both with equal interest from management.

The three most common parameters monitored are basis weight, moisture, and thickness. New products are being offered that look at strength, gloss, formation, ash, and others. On the optical side, brightness, color, and opacity have always been important, but newer ways of obtaining the specifications instantaneously have improved response time and evaluation for future processing in smaller and more technologically advanced devices.

The most significant development involving nearly all grades of paper has been the installation of sensors that track cross-machine direction and machine direction. Signals are translated from the scanner to the computer to an actuator handling the area, and action is taken. Suppliers have been aggressive in obtaining pieces of the actuator business lately.

The cross-direction market is one-third saturated with most sensors being for moisture and basis weight control. Knowing that there is plenty of growth potential in sales for actuators and their new cousins (sensors), suppliers have introduced a wide variety of equipment over the past 12 months.

Measurex Corp., unveiled its digital strength sensor that uses a technology developed at the Institute of Paper Chemistry. Field evaluations have shown close correlations between lab tests and the sensor for burst, tensile, total energy absorbed, and STFI crush. It has been successful in measuring strength variations, optimizing physical property targets while reducing production costs, and allowing a better understanding of how physical properties are affected by process variables. The sensor has been operating on machines at Owens-Illinois Inc., in Valdosta, Ga., Longview Fibre Co., Longview, Wash., and other mills.

Measurex recently entered into a joint agreement with Beloit Corp. to work together on new paper machine systems integrating their product lines. Exchanges in process knowledge as well as further product development may follow.

Earlier in the year, Sentrol Systems was acquired by Valmet Auto-

TABLE 3: **Select survey results for various paper grades.**

Grades	Property	Chief method	Target range
Uncoated			
20 lb-76 lb	Smoothness	Sheffield	100 ±50
	Brightness	Photovolt	85 ±GE
	Moisture	Online	5 ±0.5%
Tissue			
9 lb	Brightness	ISO	80 ±4%
	Absorption	Water drop	1 ±0.5 sec.
	Basis weight	Online	9 ±0.2
Newsprint			
30 lb	Absorption	Water drop	17 ±6 sec.
30 lb	Brightness	ISO	60 ±5%

mation. They have released a new package for their sensors called the Optiscanner. The Optiscanner is designed to protect sensing components against contaminants and to allow access and maintenance while the machine is running. Among the more recent sensors for this scanner are the Poly-Surf analyzer, which checks gloss and scattering, and the Formatone, which defines formation. The controls can be watched by the latest in modular computer control, the Sentry XD.

AccuRay is also actively developing actuators. After being acquried by Combustion Engineering, AccuRay has seen forward integration of the product line has come to fruition. Products include: the Linear Steppe Actuator (slice adjustment), the Thermo-Profiler Actuator, and the Water Spray Actuator. AccuRay has also introduced a new housing system for these sensors called the Microscan Measurement Platform. The scanner can now house the ultrasonic strength sensor and Opti-Pak formation sensor, as well as all other previously released products under the Microscan banner. AccuRay also has a package for the supercalender, now featuring a gloss sensor.

After their highly successful InfraPac system, Impact Systems is now offering some redundancy and a faster actuator response time through a product called the RT nonscanning moisture measurement sensor. The sensor is designed to work with existing profilers, which now take at least one scannng period (30 to 60 seconds) to invoke corrective action. The RT system consists of a stationary array of sensing elements placed in three-inch zones across the sheet, which are capable of measuring CD data every two seconds. The result of this data acquisition and evaluation is an almost instantaneous response. This ability to react quickly to short-term variations makes this sensor ideally suited for the heavier grades. The system is currently online at Union Camp Corp., in Montgomery, Ala., and Georgia-Pacific Corp., in Monticello, Miss.

OFFLINE AUTOMATION. The past six years have seen a complete turnaround in the paper testing lab supporting production. In the past, labs have been ineffective for real-time evaluation and resolution. Management of all resources of the lab were lax and the support function of the lab became a scapegoat for customer problems. But when the dollar went up and imports rose, particularly for the value-added products, quality became a central issue in regaining strength in the maintained and lost segments of the market.

The advent of the microprocessor radically changed test equipment. Now the data acquisition and management equipment are bringing testing information to the production floor, restoring the support function for which the labs were originally intended. The labs are now able to provide production personnel with a larger picture of their process. As more managers and engineers employ statistical methods of evaluation in process and quality control, the need for reliable data and complete knowledge of the sampling universe is imperative for solidifying confidence in the results.

Most mills have purchased modern instruments using digital readout and solid-state electronics. The degree of sophistication of a device is often dictated by its price, so the type of equipment the mill will get is specific to the amount of funds allocated for each part of the lab. The result is a varied and wide-ranging picture of paper testing in domestic mills.

Some mills have attempted to upgrade their labs by installing a microcomputer to facilitate storage and acquisition. This step can provide a false sense of security in that labor has been added but automation has not taken place. Slowly but steadily mills are placing automatic testing features in the labs with equipment using leading-edge technologies like robotics and artificial intelligence.

Suppliers have used several approaches to introduce their products. All have been reasonably successful and should see more growth in the future. Also, advances in the electronic industry will probably keep development active.

In fully automated systems, a product called the Testream, marketed by AcquiData, Inc., of New Rochelle, N.Y., can interface over 100 of the current offline testing machines and deliver the information automatically to every area of a paper mill. In a recent example of how Testream is used, a mill testing with 16 instruments needed information pulled from the tests done in several areas in the mill, so it employed the following procedure. The processed data was routed to terminals on the machine floor, sent to a mainframe, dumped into a database, and was also made available to production teams who employed a statistical package for process capability studies.

The concept of filling those requests from the testing lab may have been basic, but the electronic engineering and design of the system was extremely complex. The product was in development four years and has been on the market for two years. A key feature is the remote support, as maintenance can be handled from the manufacturer's location. The system is used by a wide variety of paper grade manufacturers and research labs. A customer from Japan told

TABLE 4: **Regional brightness targets for white papers.**

Region	Grade	Brightness
East	Uncoated & coated freesheet	86 GE
	Market pulp	90 ISO
	Newsprint	70 GE
South	Market pulp (hardwood)	91 GE
	Market pulp (softwood)	90 GE
	Bleached board	88 GE
	Uncoated & coated freesheet	86.5 GE
	Tissue grades	88 GE
West	Market pulp (softwood)	91 ISO
	Newsprint	68 GE

a TAPPI audience recently that productivity in his testing labs has jumped 50%.

RoboTest is offering multi-test apparati called the PaperLab and the MicroLab. Each processes a sample in a stand-alone unit and reports on standard tests (up to 16 for the larger unit) that are performed simultaneously. The system can be programmed for TAPPI, CPPA, ISO, and SCAN testing procedures and standards. The correlation of PaperLab results with TAPPI standards are said to be less than +1.0%. The units have been installed at six locations in North America--on newsprint (Kruger, Quebec), coated paper (Niagara of Wisconsin), and four other unnamed mills.

An example of the innovative opportunities of using a PaperLab comes from the Summa Mill of Enso-Gutzeit OY (Finland). Here the PaperLab-16 is situated between the dry ends of two paper machines. The production department at this mill has the responsibility of testing each reel. The reporting feature focuses on the exception rather than just data. If a specification is off, the report indicates to what degree. This gives the machine operators the ability to accept and reject paper and correct the process without having to wait for an evaluation from the technical department.

In North America this unit has helped boost the productivity of mill laboratories. Reels are tested much more frequently than in the past (from "every so often"--by shift or reel number--to nearly every reel) without an increase in testing costs. The return from a purchase comes in three ways: reduction of labor, enhanced quality maintenance and control (difficult to assess accurately), and optimization of process variables (the greatest being raw material inputs, which are easy to assess). Returns can be realized within eight to 18 months for most mills.

On the optical side, the microprocessor has made several tests available on one device. Jamming many tests into a single instrument has reduced labor and time in receiving data. Technidyne is now marketing a product for testing brightness, opacity, color, scattering, and other parameters, and also a printer that prompts the technician during the acquisition. Hunter Associates, whose founder was the pioneer of online optical property measurement, maintains its successful instruments that watch color, brightness, gloss, and other appearance characteristics. The latest feature is making the testing machine's information available to microcomputers.

In the strength testing area, the major changes have been in computerization, console control, user-friendliness, and now, robotics. Instron, famous for its products in tensile testing, has sold a half-dozen systems that employ robots for sample loading and testing. Information can then be sent to a microcomputer where the software generates a report on the present set of data. Thwing-Albert Instruments, which is the only manufacturer of Elmendorf tear testers until recently, is also automating its product. Signals from these testers can also be received by microcomputers and processed according to the user's needs.

Testing Machines Inc. has recently introduced a line of compression testers capable of many new functions not available with previous models. Acceptance of the new testers is reportedly high. TMI is also marketing a data acquisition device known as the Monitor X series, which is equipped with other TMI testers or can be interfaced with existing testers. The Monitor series allows users to build a fully automated lab, as each piece is a stand-alone, intelligent work station. The signals are sent to a microcomputer for use in word processors, databases, and spreadsheets.

Interestingly, the development of testing instruments is quite often driven by customers. This is somewhat of a unique situation. Many suppliers commented that their instrument, or one by a competitor, was not providing data as completely as was deemed necessary in evaluating product quality. An example of this situation is the stiffness tester sold by TeledyneGurley, where the instrument is being redeveloped. Customers required a more defined quality of stiffness and more usable test data with which to predict or associate particular process variables. The result is a new measuring device and a clearer picture of the stiffness characteristic.

The research associations have also been active in developing testing equipment and methods. IPC cultivated a runability measurement for corrugating medium that checks fracture points. It is now sold by Liberty Engineering. STFI has been active in developing compression testing for material used to make boxes (marketed by Scanpro).

SUMMARY. Paper testing is riding a high-tech wave that could go on indefinitely. Archaic instruments and paper testing evaluation, the majority of which most papermakers have been exposed to, are gone and will be quickly forgotten. Labor has been reduced and reliablity has been restored. New equipment and chemicals have produced products faster and with better quality, and today's labs can actively contribute to those profit centers.

The online testing in mills today is truly remarkable. Initiating corrective action to well-designated actuators for maintaining the product quality in each individual reel is progress. And such progress is desperately needed to compete in an international market that is relentlessly expanding. Mills installing the online sensors are more than satisfied with the results, and many have commented that a future has been ensured for them through a new confidence in their products.

Offline automation will also continue, and the integration of information with the online devices can be managed in such a way as to guarantee competitive quality products. This situation is creating a healthier production environment that can withstand the economic cycles prevalent in today's world paper industry.

SECTION III:
THE STATISTICAL APPROACH TO QUALITY

No matter what standards pulp and paper mills use to measure the quality of their products, chances are very good that they will be using statistical quality control SQC, or statistical process control SPC, to make sure those products will consistently meet their standards. In fact, many manufacturers are going a step further and demanding that suppliers of their raw materials also apply SQC to their products, as they in turn are being required by their customers to implement SPC.

Statistical process control is defined as the application of accepted statistical methods to determine if a given process is within the operating control limits established by those statistical methods. Statistical quality control is the application of accepted statistical methods to determine if a given process is within the operating control limits established by those statistical methods and is producing a product that may be shown statistically to be acceptable for the end-use requirements. These statistical methods attempt to minimize the variation in both the process and the product, while constantly trying to reduce it.[1]

SQC/SPC is based on the philosophy of Dr. W. Edwards Deming, an American statistician, as described in the book *Quality, Productivity, and Competitive Position*, published by the Center for Advanced Engineering Study at the Massachusetts Institute of Technology. Dr. Deming taught his philosophy to the Japanese to help them rebuild their industry after World War II, and SQC/SPC techniques have helped make Japan the industrial powerhouse it is today. It may seem surprising that the highly touted Japanese management techniques are actually based on the teachings of an American; however, there is no doubt about their effectiveness and the results achieved. Dr. Deming's "14 Points for Management." are listed in Table 1.

Federal Paper Board Co.'s Riegelwood, N.C., mill was the first U.S. operation to apply SQC/SPC to pulp- and papermaking. Federal Paper began its SQC/SPC program in 1982.[2] However, it is safe to say almost every pulp and paper manufacturer has begun or will implement an SQC/SPC program.

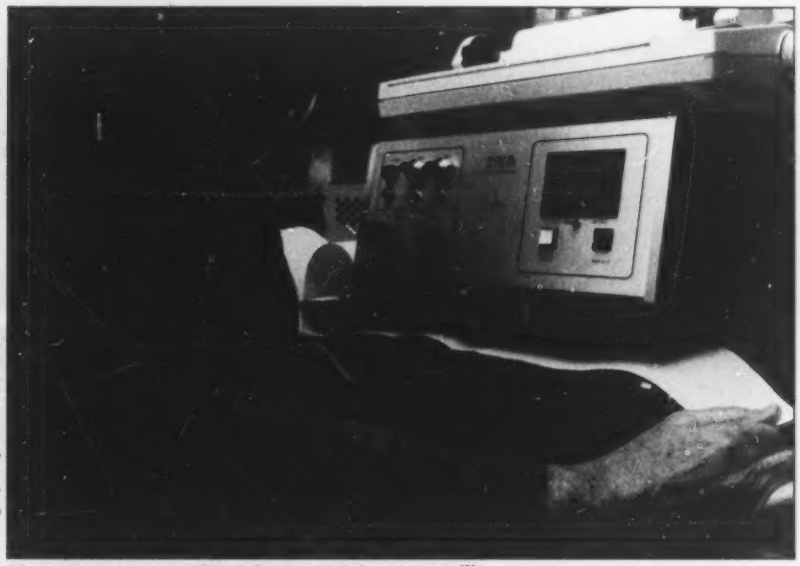
Some common notions of SQC/SPC teachings are:[2]

- Workers want to do a good job
- Workers work within a system
- Approximately 85% of all problems are systems or management problems that must be corrected by management
- It is cheaper to make something right the first time
- Quality must be controlled at every step in the manufacturing process, not just at the end
- SQC/SPC is not a quick fix
- SQC/SPC must be used forever to achieve constant improvement
- For SQC/SPC to be effective, it must have full commitment and involvement of management
- An SQC/SPC program must be designed with an implementation plan.

MEASURING VARIATION. Manufacturing processes for making cars or paper, all vary somewhat from week to week, from day to day, and from minute to minute. Much of this variability (probably 85%) is really due to chance and is not within the normal control of the operators. However, the basis of SQC/SPC is that this variability can be measured, and it can be separated into assignable causes that, once identified, can be eliminated one by one, either by the operators or with the help of the operators. It can also be separated into common causes that, once identified, can only be eliminated by management actions. According to

Photograph by Steve Dinberg

Final inspection for quality at Georgia-Pacific's Palatka, Fla., tissue converting operation.



Photograph by Jim Robinson

Measuring paper profile at Crossett, Ark., paper mill.

SQC/SPC, it is much better for the operators to leave systems alone if they are dealing only with common causes. By eliminating assignable causes and working to reduce common causes, variability is decreased and quality is improved.

Rather than make random or misguided adjustments to the process, operators plot certain variables to statistically identify and separate variations that should be corrected by operator-initiated actions from those caused by the nature of the process itself or by chance. Data that is relevant to the process must be collected and put into a picture/graph form so that the operators can readily see what is happening. This picture/graph, known as a control chart, is a line graph that has been enhanced with control limits--lines placed at plus or minus three standard deviations from where the process normally runs. Figure 1 is an example of a control chart used by Federal Paper at Riegelwood for batch digester K number control.[3] The limits on this chart allow each operator, whether experienced or not, to see any particular point on the profile as either "good" or "bad." There is no need for judgment calls because the limits define where the natural variation ends and the unnatural variation begins.

Most SQC/SPC functions use two types of control charts--the X-bar, or average, chart and the range (R) chart. An X-bar chart is usually kept by the operators in conjunction with a range chart. The X-bar chart tells where the process is running on the average, while the range chart tells how much variation there is from sample to sample. When a range chart kept on an automatic process goes out of control (out of the control limits), it normally means that the equipment needs adjustment or repair. If a range chart kept on a manual process (such as multiple tests run on the same sample in a laboratory) goes out of control, it usually indicates that the person running the test is not using the same method of testing from sample to sample.[4] It is important to note that the average and control limits are statistically determined for the process in question and do not represent targets or standards. Standards may be arbitrarily imposed and may not represent what a process is actually capable of achieving.

TABLE 1: **Dr. Deming's 14 points for management.**

1. Create constancy of purpose toward improvement of product and service.
2. Adopt the new philosophy: acceptance of poor product and service is a roadblock to productivity.
3. Cease dependence on mass inspection; replace by improved processes.
4. End the practice of awarding business on the basis of price tag alone.
5. Find problems and fix them; continually reduce waste and improve quality.
6. Institute modern methods of training on the job.
7. Institute modern methods of supervision.
8. Drive out fear.
9. Break down barriers between departments and locations.
10. Eliminate numerical goals, posters and slogans. Don't ask for new levels of productivity without providing methods.
11. Eliminate work standards and numerical quotas.
12. Remove barriers that stand between the worker and his right to pride of workmanship.
13. Institute a vigorous program of education and training.
14. Create a structure in top management that will push every day on the above 13 points.

STARTING A PROGRAM. Most mills view the SQC/SPC programs as an enhancement of their quality control and/or human resources programs. Much of the statistical manipulation and plotting of process variables required by these programs could easily be done by the process control systems in place at mills. However, a key to these programs is getting the operators more involved and aware of the process. Therefore, most SQC/SPC programs involve manual plotting of data points on the control charts by operators. SQC/SPC helps make operators more aware of what the process is doing and enables them to take proper corrective action sooner. It requires that operators communicate with each other and become more concerned with quality.

The decision to begin an SQC/SPC program must necessarily be made by upper management, and the implementation of such a program requires a strong management commitment to succeed. Upper management may then form a steering committee which includes a cross-representation of personnel from manufacturing, financial, and marketing management. An SQC/SPC implementation team will usually be formed. Many companies feel they need a staff "champion" to act as house expert and oversee the program. A champion like that may have received training in SQC/SPC techniques from an organization such as Tennessee Associates in Alcoa, Tenn. Tennessee Associates has trained people from ten U.S. pulp and paper companies in SQC/SPC implementation techniques as part of its "Managing for Consistency" program. It emphasizes that statistical techniques are only part of a quality improvement program and that assessment and improvement of the "culture" is also necessary.

The first step in implementing an SQC/SPC program at the mill level is usually a pilot project that monitors a few variables such as brightness, K number, moisture, basis weight, or coat weight. The variable(s) chosen for plotting are those that are important because they affect the quality of the process and are controllable by the operators. Variables are added as the program progresses. As an example, Federal Paper's Augusta, Ga., mill, currently plots control charts for 23 variables in the paper mill (three machines) alone.[1]

A large quantity of data is gathered and plotted to determine the natural variability of the process and set the initial control limits. The time period covered by this data must be sufficient to be a representative sample, and it may vary from one day to one year or more depending on the process. From the analysis of the baseline data, control charts are constructed. Foremen and supervisors are usually trained first in SQC/SPC techniques and theory. Operators are trained next with a con-

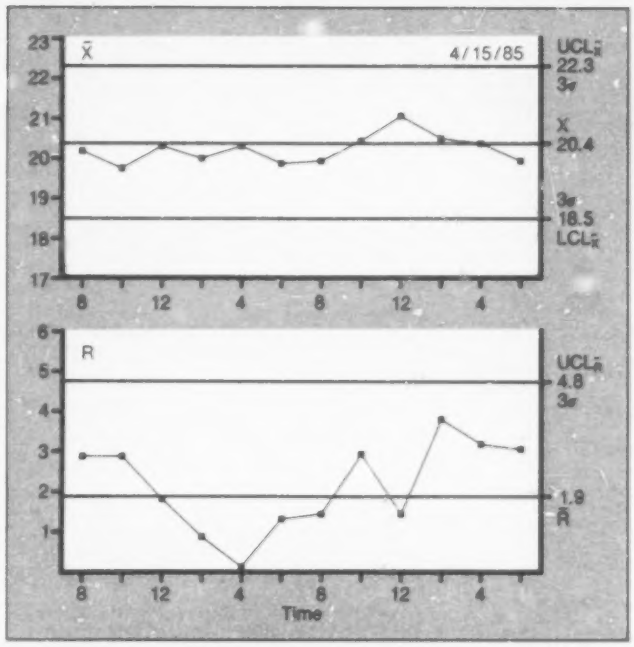


FIGURE 1: **Control charts for a batch digester, K numbers used at Federal Paper Board.**

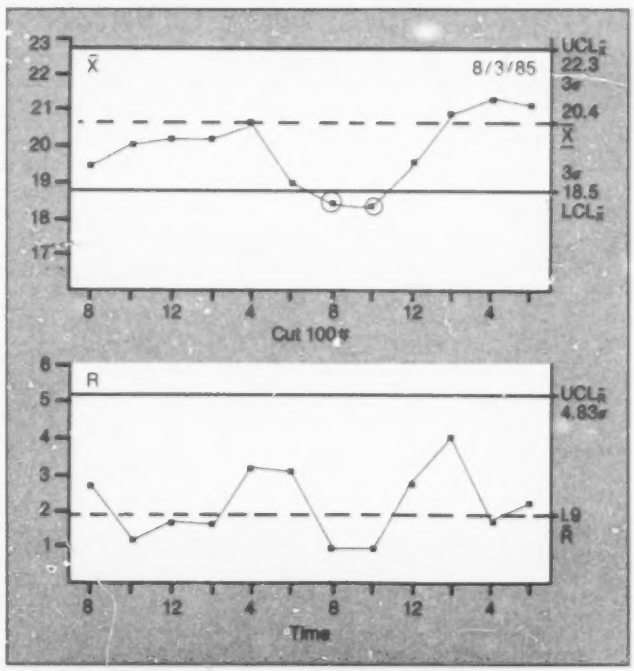


FIGURE 2: **K number control charts showing the process out of control at 8:00 and 10:00 p.m.**

Guidelines for success in SPC

1. Have a person knowledgeable about both your process and statistics either in the organization or as a consultant to keep the program on track
2. Use people who are primarily process oriented for the day-to-day upkeep and maintenance of the system
3. Stick to simple statistics
4. Introduce SPC to the operators as another tool for them to use so they can do their jobs better and easier
5. Keep moving forward, rarely stand pat

centration on implementing the program. The curriculum may include the philosophy behind the program, how to use a calculator, basic mathematical concepts (such as how to plot an average and a range), and how to plot and read points on a line graph. They also learn to make control charts in order to understand what a control chart is and how to use one.[4]

In the example of the control chart shown in Figure 1, operators were plotting the three-term moving average (X-bar) and range (R). The three-term moving average is used for the K numbers because it dampens swings in the data points, analogous to mixing that will occur in latter stages of the process. Use of a three-term average also reduces op-

FIGURE 3: **Example of control chart data calculation and plotting for hypothetical paper test values.**

Data for variables control chart ($\bar{X}$ & R)

Reel averages and ranges
(5 tests per reel/subgroup)

Reel Number	$\bar{X}$	R	Reel Number	$\bar{X}$	R
1	55.4	2	16	55.8	4
2	54.8	3	17	52.4	7
3	53.6	7	18	54.8	3
4	54.0	6	19	54.2	3
5	54.4	6	20	54.0	4
6	54.0	8	21	55.2	4
7	54.4	4	22	55.0	6
8	54.2	3	23	55.2	4
9	54.2	4	24	54.8	8
10	53.4	5	25	55.2	1
11	53.8	5	26	54.0	2
12	53.2	3	27	53.4	3
13	53.2	3	28	53.6	5
14	54.2	2	29	52.8	5
15	55.2	4	30	55.2	3

$\bar{X}$ = Reel average.
$\bar{\bar{X}}$ = Overall average.
R = Reel range.
$\bar{R}$ = Average range.

Control limits for $\bar{X}$ and R charts
(From statistics handbook)

Number of observations in subgroup, N	Factor for $\bar{X}$ chart A_2	Factors for R Chart: Lower control Limit, D_3	Factors for R Chart: Upper control Limit, D_4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.78
10	0.31	0.22	

$\bar{X}$ (for each subgroup) = $\frac{\text{sum of measurements in subgroup}}{\text{number of measurements in subgroup}}$

$\bar{\bar{X}}$ (central line) = $\frac{\text{sum of } \bar{X} \text{ values}}{\text{number of subgroups}}$

$\bar{R}$ (central line) = $\frac{\text{sum of R values}}{\text{number of subgroups}}$

$\bar{X}$ Upper Control Limit: $UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R}$
$\bar{X}$ Lower Control Limit: $LCL_{\bar{X}} = \bar{X} - A_2\bar{R}$
R Upper Control Limit: $UCL_R = D_4\bar{R}$
R Lower Control Limit: $LCL_R = D_3\bar{R}$

Calculation of control limits

$\bar{\bar{X}} = \frac{1827.5}{30} = 54.25$

$\bar{R} = \frac{126}{30} = 4.2$

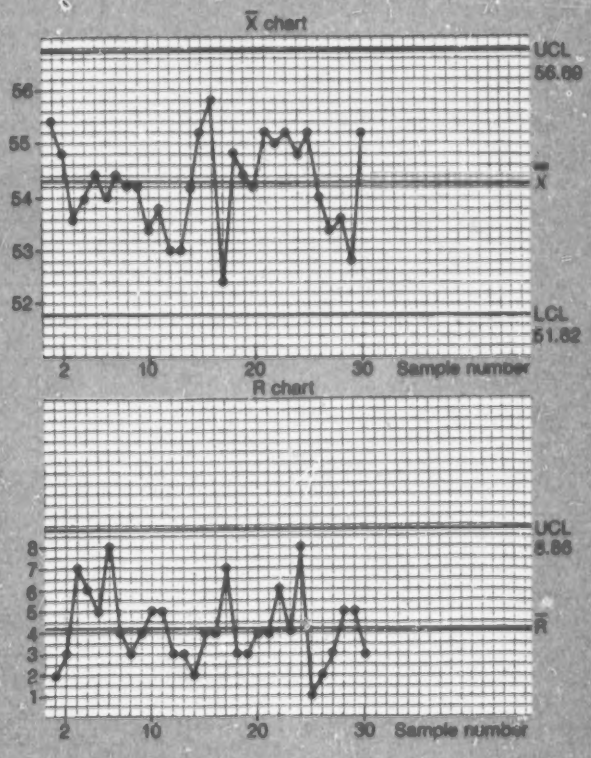
$\bar{X}$ Upper Control limit: $UCL_{\bar{X}} = 54.25 + (.58)(4.2) = 56.69$

$\bar{X}$ Lower Control Limit: $LCL_{\bar{X}} = 54.25 - (.58)(4.2) = 51.82$

R Upper Control Limit: $UCL_R = 2.11\ (4.2) = 8.86$

R Lower Control Limit: $LCL_R = 0\ (4.2) = 0$
No lower limit for range

$\bar{X}$ R charts



Example courtesy of Vann Parker, technical and quality assurance mgr., Federal Paper Board Co., Augusta, Ga.

erators' reactions to events that, simply by the operators' response to them, would tend to increase variability. In this example, when the process is in statistical control, the average and range of the K numbers will fall within the control limits, and the running average will straddle the long-term average. When points violate the control limits (UCL_x, LCL_x) there is a 99.7% probability that an upset has occurred. In other words, the control limits define the short-term, natural variability of the process. When the three-term running average or range falls outside the control limits, it means something abnormal has happened. The control chart itself does not reveal what has happened, only that an upset has occurred. Then it is up to the operators to identify and report the problem and take appropriate corrective action when possible.

Figure 2 shows another Federal Paper control chart for K numbers where the running average drops sharply (at 6:00 p.m.) and violates the lower control limits on the average chart (at 8:00 p.m.).[3] The operator recognizes from the 6:00 p.m. entry that an abnormal event has occured and takes a small control action. The process responds six hours after the operator intervention by coming back within the normal control range statistically determined for this process. In this case, six hours is the theoretical residence time from the beginning of the cook to when the test is called in from the lab.

The use of control charts allows the operators to determine when a process upset has occurred. The operators then use their knowledge and grasp of events to decide what, if any, control action is warranted. Without control charts, the operators have to rely on their experience and intuition to determine when it is necessary to intervene in the process. Often, when control charts are first determined for certain variables, management will note that the limits are actually much wider than wat would have been considered acceptable operating practice. This is because, prior to SPC/SQC, normal process variation was sometimes interpreted as an upset, leading operators to over-control their processes.

Figure 3 is an example showing data manipulation and plotting for a hypothetical paper test with five tests per reel.[1]

BEYOND CONTROL CHARTS. The SQC/SPC programs, once implemented, can go far beyond the generation of control charts. To help determine causes for points outside the control limits, Ishikawa diagrams may be prepared by management with the operators' input. These diagrams, sometimes called "fishbone charts," offer a systematic cause-and-effect way of identifying the real source of specific problems (Figure 4).[5] In addition, the complex relationships between the process variables can be more clearly understood. As causes for points out of control are identified, charts are prepared to quantify and rank the most frequently recurring ones. The charts, called Pareto diagrams, are useful in directing management's attention to the most serious, and the most easily corrected, problems. Figure 5 shows a Pareto chart from Federal Paper ranking system problems causing batch digester K number variations.[3] Obviously, to achieve significant improvements in quality, it is necessary to deal with the most frequent problems. Most of the problems identified by the bar chart in Figure 5 are not cross-hatched. The cross-hatched areas represent only those events over which the digester operators have direct influence. Without a statistically based program, it would be easy to blame the operator for process upsets.

Photograph by Rod Reilly

Testing properties of linerboard and corrugating medium at G-P's Doraville, Ga., Container Div. technical center.

Quality control testing at Stone Container's Missoula Mont., mill.

Consolidated Papers at Wisconsin Rapids, Wis., has begun using a variation of the conventional control charts called a "zone control chart" (Figure 6).[6] The zone control chart procedure uses statistical tests for detecting a process shift, as shown in the *Western Electric Statistical Quality Control Handbook*. It is said to be a simplification which eliminates many of the difficulties with control chart construction, plotting, and interpretation, and it has been called an all-purpose chart that can be applied to any data that fit the normal distribution. Another advantage is its ability to quickly distinguish special causes of variations from common ones. ■

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FIGURE 4: **Ishikawa diagram for troubleshooting process variations for bleach plant first stage ClO_2 wet Elrepho brightness.**

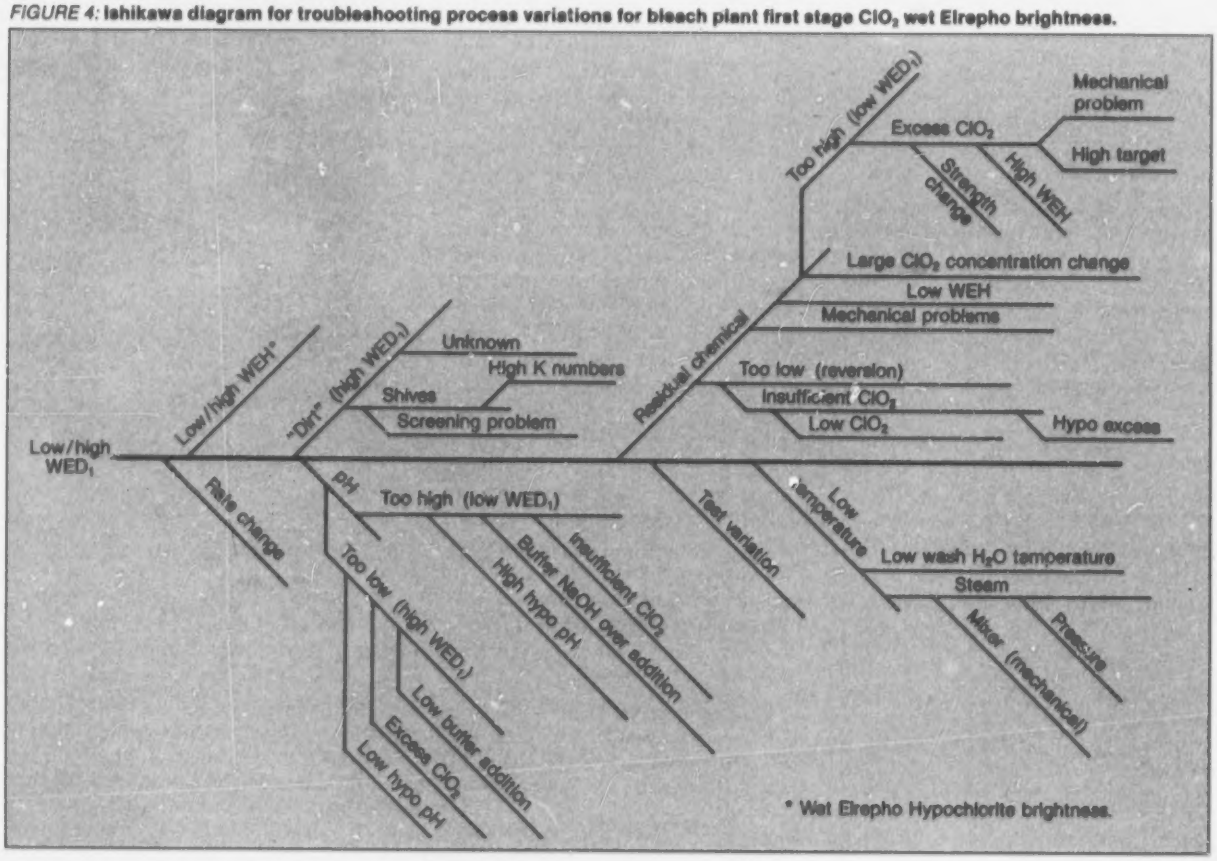


FIGURE 5: **Pareto chart for batch digester K number variations.**

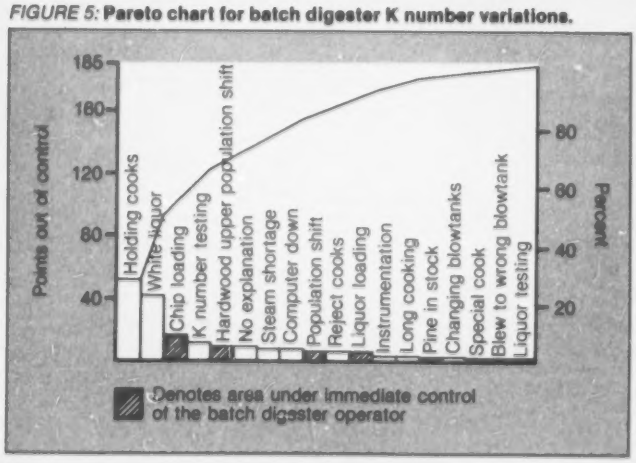
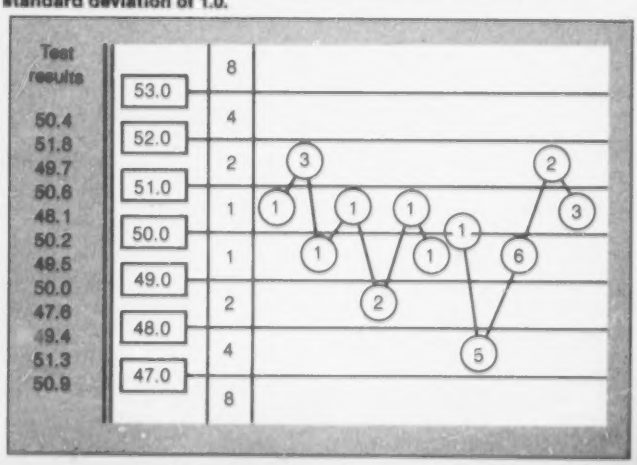


FIGURE 6: **Zone control chart for a process with a target of 50 and a standard deviation of 1.0.**



GLOSSARY OF TERMS

ABRASIVENESS: A characteristic of finished paper that indicates its potential for abrading other materials as it moves in contact with them. The degree of abrasion and wear is generally related to additives in the paperstock, as well as any "external" coatings, rather than the fibers themselves.

ABSORBENCY: That property of pulp, paper, and its constituents and products which permits the entrainment and retention of other materials it contacts, such as other liquid, gaseous, and solid substances.

AGING RESISTANCE: The ability of pulp or paper to maintain certain physical properties such as strength and brightness over long periods. Sometimes referred to as stability or permanence.

AIR PERMEABILITY: A paper sheet characteristic which allows air to pass through its fiber formation. It is measured by subjecting a specified sample to standard pressure differences across its boundaries under known conditions of temperature and relative humidity and determining the rate of airflow.

ALPHA-CELLULOSE: The portion of pulp or other cellulosic materials that will not dissolve in 17.5% strength caustic solution at 20°C.

BASIS WEIGHT: The weight, in pounds, of a ream of paper, usually consisting of 480, 500, or 1,000 sheets of a specified size as stated in the definition of the basic size for the specified grade. The standard ream size varies with different grades of paper according to trade practices. As a general reference, sometimes the weights are converted and expressed as the weight of an arbitrary standard ream of 500 sheets, 24 in. x by 36 in.

BONDING: The sticking together of papermaking fibers, which provides toughness and strength to the paper.

BREAKING LENGTH: The calculated limiting length of a strip of paper or board of any uniform width beyond which, if such a strip were suspended by one end, it could break by its own strength. Its value is calculated from the tensile strength and the basis weight of the sheet in expressing paper and pulp testing results.

BRIGHTNESS: A measure of the degree of reflectivity of a sheet of pulp or paper for blue light measured under specified light standard conditions. Same as whiteness. Usually expressed as GE or ISO, depending on instruments and procedures used.

BULK: The compactness property of a sheet in relation to its weight (Whose value decreases as the compactness increases). It is measured as the thickness of a pile of a specified number of sheets under a specified pressure.

BURST: (1) The pressure in pounds required to rupture one square inch of paper under stipulated testing procedures. The most common procedure to break the paper is by expanding a flexible diaphragm against a securely held circular area of paper. The Mullen tester is an example. (2) Refers to a defect in paper characterized by a rupture in the web not extending to the edges.

CALIPER: The thickness of a sheet of paper or paperboard, measured under specific conditions, expressed in units of thousandths of an inch. "Mils" is used when referring to paper, and "points" when referring to paperboard. Also called thickness.

CLEANLINESS: A reference to the degree of dirt or spots on paper. Several procedures, some including the actual counting of these imperfections in a small area to determine average levels in a sheet, are used to grade paper or board by cleanliness.

COARSENESS: A property of pulp related to the refining, fiber perimeter, and wall thickness characteristics as it affects the weight per unit length of the fiber.

COAT WEIGHT: Refers to the amount, thickness, etc., of the layers of mixed clays and adhesives, etc. that are applied to the surface of paper or paperboard to create a new surface.

COHESIVENESS: A refining term referring to the intrinsic attraction of fiber surfaces, which equals the shearing stress divided by the relative bonded area.

COLOR: (1) The dyes and pigmented mixtures used to treat paper or paperboard and the visual effect it produces in the product and on its surface. (2) The act of accomplishing a visual effect on paper and paperboard by using dyes and pigmented mixtures.

COMPRESSIBILITY: The amount the sheet caliper will decrease under a specified load or use. In printing, referred to as cushion.

CONSISTENCY: Referring to finished paper and paperboard, it is used to denote shipment-to-shipment uniformity. Seeuniformity.

CREASEABILITY: Physical property of paper that resists the breaking away of the surface coating along the crease on folding.

CRUSH RESISTANCE: The physical property of paper and paperboard that is resistant to compression loads.

CURL: A paper or paperboard deformation caused by nonuniform distribution of strains and stresses throughout the sheet due to uneven internal moisture and conditioning.

DENSITY: With reference to paper and paperboard sheets, it is the ratio of the weight to volume, with high-density paper and paperboard having a high weight-to-volume ratio.

DIMENSIONAL STABILITY: A sheet characteristic indicative of its ability to maintain original machine and cross-machine dimensions with time and under variable moisture and relative humidity conditions.

DIRT: Undesirable, extraneous, contaminating material in pulp, paper, or paperboard which is visible in transmitted or reflected light. *See also* cleanliness.

DRYNESS: Air dry: Refers to weight of moisture-free pulp or paper plus 10% moisture based on a traditional assumption that this

amount of moisture exists when they come into equilibrium with the atmosphere, which in actuality is dependent on the conditions of the atmosphere to which it is exposed. Air-dried weight is determined by dividing the oven-dried weight by a factor of 0.9. **Bone dry:** (1) A descriptive term for the moisture-free conditions of pulp and paper. (2) Refers to air containing absolutely no vapor. **Oven dry:** Moisture-free conditions of pulp and paper and other materials used in the pulp and paper industry. It is usually determined by drying a known sample to a constant weight in a completely dry atmosphere at 100°C to 105°C (212°F to 221°F).

FADE: The slow loss or change in color of paper. It is usually caused by exposure to light over a period of time.

FIBER LENGTH: The average length of fibers in the mass of pulp or furnish stock.

FOLDING ENDURANCE: Refers to ability of paper or board to withstand repeated bending and folding with a minimum of damage. The paper mill lab test for folding endurance is made on a specific strip of paper. It determines the number of double folds that can be made under specified tension conditions before it will break and is a measure of the folding properties of the sheet.

FORMATION: The physical distribution and orientation of fibers and other solid constituents in the structure of a sheet of paper which affects its appearance and other physical properties. Also referred to as look-through because the formation can sometimes be observed by looking through the sheet.

FREENESS: The ability of a paper and water mixture to release or retain water on drainage. The ease or lack of ease with which the mixture or slurry will drain water is sometimes referred to as slowness or wetness. Usually measured as Canadian Standard freeness (CSf), referring to a specific test procedure.

FUZZ: Fine fibrous extensions that occur on paper and paperboard surfaces. These fibrous extensions are the result of improper refining in the stock preparation area, the use of excessive vacuum during the sheet formation phase, or the use of insufficient sizing material.

GLOSS: That property of a paper sheet surface that produces a shiny, highly reflective appearance when light is reflected from on it. See Reflectance.

GLUABILITY: The measure of paper or paperboard's ability to accept or "hold" glue, i.e., to be glued.

GREASE RESISTANCE: The ability of paper or paperboard to resist the penetration of oil or grease. A greaseproof paper is a protective wrapping specially coated with materials to make it resistant to grease or oil, or the stock that it was made from was highly hydrated by mechanical refining of chemical woodpulp to make it greaseproof. Coatings include casein, lacquer, hotmelt, resin, or silicate--this type of paper is generally referred to as glassine.

HANDFEEL: A term used to express the impression obtained by handling paper to judge its finish, flexibility, and general quality.

HARDNESS: (1) The physical characteristic of paper or paperboard related to its resistance to damage by impact. (2) The density of a rubber covering on press rolls. (3) A water quality related to the calcium, aluminum, iron, and magnesium concentration.

HOLDOUT: The ability of paper or paperboard to resist surface liquid penetration.

HYDROEXPANSIVITY: That property of a sheet of paper related to the dimensional change occurring during a change of relative humidity of the surrounding air.

INK RECEPTIVITY: The ability of paper and paperboard to take up and retain oil-based type inks.

INTERNAL BONDING STRENGTH: The sticking together of fibers within the paper or paperboard sheet structure that provides toughness and strength.

JOB LOT: Out of specification, defective or discontinued types of paper. It is made up in small quantities for special orders and sometimes sold at a lower than standard price.

KAPPA NUMBER: A value obtained by a laboratory test procedure for indirectly indicating the lignin content, relative hardness, or bleachability of higher lignin content pulps, usually with yields of 70% or more. It is determined by the number of milliliters of tenth-normal permanganate solution (0.1 $KMn0_4$) which is absorbed by 1 gram of oven-dry pulp under specified conditions and is then corrected to 50% consumption of permanganate.

LATENCY: The curl and spiral of individual pulp fibers produced during the mechanical action in refiners, especially in the thermomechanical pulping process.

MOISTURE CONTENT: The percent of water by its weight in paper, pulp, paperboard, chips, etc., which will vary according to atmospheric conditions because of the ability of these types of materials to absorb or emit moisture.

MOISTURE RESISTANCE: The ability of paper and paperboard to resist the penetration of water and water vapor.

OFF-SPEC: Shipments of paper received by customers that are not of the specifications ordered.

OPACITY: That ability of paper to resist the transmission of both diffuse and nondiffuse light through it. It prevents show-through of dark printing in contact with that backside of a sheet of paper. See also Show-through.

OUT-TURNS: Paper samples of orders run on a paper machine and used for mill or customer records.

PERMEABILITY: That property of paper and paperboard directly related to the ability of a fluid to penetrate and spread throughout the sheet.

PICK: (1) The phenomenon of pulp or fibers pulling away and sticking to the paper machine parts they come in contact with, such as rolls, in the wet end and dry end sections. (2) A paper mill control test to determine surface adhesion properties of paper. (3) The small particles of paper which loosen from the surface of paper, especially during printing.

PITCH CONTENT: The amount of pitch in pulp, paper or paperboard. Pitch is a resinous substance that is a combination of unsaponifiable organic chemicals mixed with resin or fatty acids, and exists in mechanical and unbleached chemical pulps.

PLY BOND STRENGTH: Refers to the ability of layers or plies of paperboard to adhere together and not separate or delaminate. Normally, there are two plies formed and "bonded" together during formation (multiple headboxes and sometimes multiple forming wires) on the paper machine.

POROSITY: That property of paper and paperboard related to the ability of fluids to pass through them. It is an indication of the size, shape, and distribution orientation of the pores in a sheet and the compactness of the fibers.

PRINTABILITY: The ease with which paper can be printed to high quality standards with the least amount of spoilage.

REFLECTANCE: The light-repelling ability of the paper surface, also referred to as gloss, and expressed as the ratio of the intensity of the light repelled to that repelled from a standard reference.

RUNABILITY: (1) In the paper mill, it refers to how well pulp stock furnish to the paper machine forms a sheet on the wire and passes through the drying and finishing operations. (2) Used by customers in reference to how well the paper performs in their converting operations, such as on printing presses.

SHIVE: Uncooked or undisintegrated bundles of fibers or splinters in woodpulp that may show up as imperfections in the finished sheet of paper made from it, if not previously removed. It is also found in groundwood pulp. Sometimes called slivers.

SHOW-THROUGH: The resistance of a paper sheet to transmission of both diffuse and nondiffuse light so that any printing on one side cannot be seen from the other side. *See also* opacity.

SMOOTHNESS: The surface property of a paper sheet related to its degree of uniform flatness and evenness. It is sometimes measured by the rate of flow of air between two or more sheets or between one sheet and a smooth standard surface.

STANDARD CONDITIONS: Unless otherwise specified, it is assumed to be 29.2 in. of mercury and 70°F.

STIFFNESS: That ability of paper or paperboard to withstand bending or crushing forces. Also called rigidity.

STRETCH: The elongation of paper before rupture when tension is applied. It is measured as a percentage of the original length.

STRIKE-THROUGH: Penetration of ink through a sheet of paper so that it shows through on the unprinted side.

SURFACE SCUFF: Also known as scuff resistance. The ability of paper and paperboard to withstand the lifting of fiber when rubbed on another surface. It is measured by a laboratory instrument consisting of an element of fixed weight and size and rotates at a fixed speed on one spot of a sample sheet.

SURFACE STRENGTH: The resistance of a paper sheet to the removal of fibers from its surface. It is measured by pulling a series of arbitrary grades of melted and then cooled wax sticks from its surface. The measurement procedure is called a wax pick test.

TACK: The sticky property of paper and paperboard adhesive and gluecoating materials. Also, printing inks.

TEAR STRENGTH: The resistance of a paper sheet to tearing. It is usually measured by the force required to tear a strip under standardized conditions. Tear factor is the tearing force divided by the basis weight in grams per square meter multipled by 100.

TENSILE STRENGTH: The resistant property of a sheet to pull or stress produced by tension. It is expressed as force per unit width of a sample tested to the point of rupture.

THICKNESS: The dimension of a sheet of paper or paperboard usually measured between the two surfaces under specifically stated conditions and expressed in thousandths of an inch as its caliper.

UNIFORMITY: The sameness of certain quality, character, or property of pulp, paper, or paperboard, such as brightness, strength, color, finish, distribution of fibers, formation, etc.

WATER DROP TEST: A test used on folding boxboard to measure the degree of sizing.

WATER REPELLENCY: The resistance of paper and paperboard to wetting by water. It is the ability of these products to hold water. Water absorption is the amount of water absorbed in a given time by one side of a unit area of paper or paperboard placed horizontally under a head of 1 cm of water (Cobb test).

WET RUB: The ability of wet paper to withstand the lifting of fibers or scuffing when rubbed by or on another surface.

WET STRENGTH: The tensile strength of a sheet of paper when completely wet; sometimes calculated as a percentage of its dry strength.

WRINKLE: Paper defects appearing as puckers or creases, caused during its manufacture. The defect would be called wet wrinkle if produced while the sheet is wet, usually at the wet end of the paper machine, and dry wrinkle if produced while the sheet is dry, usually at the dry end of the paper machine.

Z-DIRECTION STRENGTH: The strength of paper and paperboard as related to the force and measured by means of tension applied perpendicularly to the test sample surfaces.

ZERO SPAN TENSILE TEST: A test sometimes made on paper to indicate the amount of sheet strength due to fiber binding.

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THE TAX REFORM ACT OF 1986: BOON OR BANE FOR THE PAPER INDUSTRY?

While the new tax law may widen cyclical swings in earnings, it shouldn't significantly affect long-term capital investment

By EVADNA S. LYNN

On balance, Merrill Lynch Capital Markets believes the Tax Reform Act of 1986 will have a relatively neutral effect on the paper industry. After the 1987 transition year, tax reform shouldn't significantly hurt the reported earnings of the major forest products and paper companies. The effect on cash flow is likely to be greater, but it will probably be less detrimental than originally indicated by many industry executives. The new Tax Reform Act's effect on capital investment and prices is likely to be nominal, with business cycle swings continuing to play a greater role than taxes in investment and price trends.

MAJOR NEW PROVISIONS. The Tax Reform Act has three major provisions affecting reported book earnings for the forest industry:

- The drop in the basic corporation ordinary income tax rate from 46% to 40% in 1987 (for companies on a calendar fiscal year) and to 34% in 1988.
- The elimination of timber capital gain treatment. Beginning in 1987, the tax rate on capital gains will be 34%. Because of the lower tax rates on ordinary income, capital gains treatment provides the equivalent of only one-third the previous tax shelter during 1987 and no tax shelter in 1988 or afterward. Capital gains terminology, however, has been preserved.
- The elimination of investment tax credits, retroactive to Jan. 1, 1986. Certain investments, however, qualify for those credits if they are completed during 1986, and a small number of companies have credits on future projects that have been "grandfathered" into the tax new law.

In addition, cash flow will be affected by two further provisions:

- Changes in depreciation provisions that tend to elongate the period over which an asset can be depreciated. This is partially offset, however, by a change in the initial rate of accelerated depreciation, and it shouldn't have a significant effect on tax liabilities.
- The minimum tax provision that provides for a 20% tax rate and includes half of the excess of pretax book income over tax income as a tax preference item. The impact of this provision varies from company to company, but it would normally have a meaningful effect on tax liabilities only during the trough year(s) of a cyclical downturn in the paper or wood products industry. On balance, it will accentuate cyclical swings in industry earnings.
- Other changes in the tax law are likely to have only a nominal effect on book or cash earnings of the forest products companies.

4% GAIN/4% DROP. Our analysis of the effect of tax reform on the major forest products and paper companies leads us to the conclusion that the new tax law will be less of an influence on tax rates in the industry than will the general health of the industry. A theoretical analysis, using stable pretax income for the industry, would indicate a four percentage point increase in 1987 effective tax rates over 1986, but a comparable four percentage point decrease in 1988, back to the old 1986 level. Building in the higher pretax income that we expect as a result of price improvement and cost reduction during that period, however, suggests that the drop in effective tax rates will be even greater for 1988. Effective taxes will tend to grow at a significantly slower rate under the new tax law because the extra income will be taxed at the new marginal rate of 34% rather than the old 46% rate.

Recent and projected tax rates for the three categories of companies in the industry are listed in the accompanying table. These estimates assume a 53% increase in pretax income during 1987 and a 12% gain for 1988 for the 27 companies covered by Merrill Lynch.

The table illustrates the benefits that the old tax law provided the industry during periods such as 1985, when pricing was weak (either from the dollar's strength as in 1985 or from a business recession) and investment spending remained high. That kind of experience, with its much lower effective tax rate, would be essentially

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eliminated under the minimum tax provisions of the new law. Therefore, the risks that have been associated with low-return investments have increased.

CANCELLED TAX CREDITS. In talking with company managements, we initially were concerned about the possible effect on capital spending of investment disincentive caused by the recision of investment tax credits. More recent conversations, however, have minimized that concern for four reasons:

1. The effect may be much smaller than originally anticipated unless the economy faces a deep recession in the next few years. In general, industry management expects cash flow to decline only about one-quarter the magnitude originally projected, or within a margin of approximately 10% of cash flow projected under the old tax law.

2. The recovery in cash flow as a result of higher prices has enabled most companies to fund planned investment in high-return projects that incrementally increase capacity while lowering costs. Although there was a hiatus in new capacity announcements while the tax law was pending, several firms have finalized plans for new capacity in recent months, and other projects are under active consideration. In short, the cash flow will be available, and it will be used.

3. Increased fear of "hostile raids" has stimulated a management environment that places prime emphasis on improving returns on investment (and equity). That influence, more than the tax law, is likely to limit investment in "greenfield" facilities and generate a higher level of expenditures for high-return projects such as debottlenecking, rebuilding and converting existing machines, and adding new machines at currently developed sites.

4. The reduction of deferred tax accounts based on a 46% tax rate will not only free-up future cash flow, but when transferred to the equity accounts (probably late in 1987), will reduce debt/capital ratios and will enable companies to support a higher level of debt for investment. (For the 28 companies that are included in our coverage, that freed-up equity could be as much as $1.4 billion.)

Increased fear of "hostile raids" has stimulated a management environment that places prime emphasis on improving returns on investment (and equity.)

In a way, the new law will be a positive force for investment because it should result in less distortion of investment decisions based on the amounts of tax benefits that such investments could generate. Managements (and boards of directors) will have less margin for error in their forecasts of future economic and product trends underlying investment decisions. Thus, there will be a tendency to approve high-return incremental capacity investments faster than the higher-risk, large "greenfield" projects, although the latter will be approved when returns are available.

NO CAPACITY SQUEEZE. In our opinion, whether or not the new tax law will result in higher industry prices is a moot point. We believe that "good projects" will continue to be built and that cash-flow will be directed primarily toward the expansion of capacity; even "upgraded" production provides an expansion of capacity in the higher-value product. Since incremental capacity investments generally require far less investment per ton of new capacity than greenfield investments, we may actually see more capacity come onstream under the new tax law than would be the case if more funds had been directed toward high-cost greenfield capacity. Similarly, there will be incentive to reduce the cost of greenfield capacity, both through streamlined design and construction and through the use of new technology. Thus, we do not expect a tax-induced capacity "squeeze" that will cause a surge in paper prices. Price levels will continue to be determined primarily by changes in the economic cycle that create more significant swings in the supply/demand balance than those generated by relatively minor capacity changes. ■

TABLE 1: **Recent and projected tax rates.**

Kind of company	Effective 1985	Tax rate on book earnings 1986	1987e	1988e
17 commodity paper companies	23.4%	41.7%	43.0%	37.8%
4 consumer paper companies	39.7	41.6	42.1	36.5
7 forest products companies	27.2	36.8	43.0	38.5
28 company composite	**26.6%**	**40.0%**	**42.8%**	**37.9%**

Source: Merrill Lynch Capital Markets.
e = Estimate.